REPORT TO THE

SANTA CLARA COUNTY FLOOD CONTROL AND WATER DISTRICT

ON THE

BAYLANDS SALT WATER FLOOD CONTROL PLANNING STUDY

BY
TUDOR ENGINEERING COMPANY

IN ASSOCIATION WITH
MARK THOMAS & CO., INC.
WOODWARD-LUNDGREN & ASSOCIATES
HYDROCOMP INTERNATIONAL
PHILIP H. AREND, WILDLIFE ASSOCIATES
DR. ANDREW H. TRICE

JANUARY 1973

REPORT TO THE
SANTA CLARA COUNTY
FLOOD CONTROL AND WATER DISTRICT

ON THE
BAYLANDS
SALT WATER FLOOD CONTROL PLANNING STUDY

BY
TUDOR ENGINEERING COMPANY

IN ASSOCIATION WITH
MARK THOMAS & CO., INC.
WOODWARD-LUNDGREN & ASSOCIATES
HYDROCOMP INTERNATIONAL
PHILIP H. AREND, WILDLIFE ASSOCIATES
DR. ANDREW H. TRICE

JANUARY 1973

DONALD K. CURRLIN	LLOYD C. FOWLER
General Manager	Director of Engineering

DISTRICT BOARD OF DIRECTORS

Maurice E. Dullea, Chairman	District 4	Joe Chiri, Vice Chairman	District 1
James J. Lenihan	District 5	Patrick T. Ferraro	District 2
Frank A. Wilcox	At Large	Robert T. Sapp	District 3
R. Jack Sturla	At Large		

LOUIS W. RIGGS
STANLEY H. FROID
CARL W. OTTO
ROBERT N. JANOPAUL
DAVIS C. TOOTHMAN

PAUL E. POTTER
WILLIAM P. RIVERS
HERBERT H. LA VIGNE

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS
149 NEW MONTGOMERY STREET
SAN FRANCISCO, CALIFORNIA 94105
TELEPHONE (415) 982-8338 CABLE "TENGCO"

RALPH A. TUDOR (1902-1963)

ASSOCIATED CONSULTANTS
LESLIE A. HELGESSON
NORMAN C. RAAB
M. J. SHELTON

January 1973

Mr. Lloyd C. Fowler
Director of Engineering
Santa Clara County Flood
Control and Water District
5750 Almaden Expressway
San Jose, California 95118

TEC 443.10

Dear Mr. Fowler:

In accordance with our agreement of June 8, 1971 for consultant services for the Bay Front Levee Planning Study, there is submitted herewith the final report on the study. Additional backup material, both written and graphic, has been submitted to you under separate cover.

This report has been reviewed extensively by interested agencies and citizens in the draft stage and has been modified, where appropriate, to reflect comments made during the course of the review. It is hoped that the findings of this study may assist you and the District Board in establishing policies pertaining to the area.

It has been a pleasure working with you and with Mr. John Richardson, your project coordinator. Your cooperation and helpful participation in this study have been appreciated by all members of our study team.

Very truly yours,

TUDOR ENGINEERING COMPANY

Carl W. Otto

Carl W. Otto

CONTENTS

Letter of Transmittal ii
Contents iii

I SUMMARY OF FINDINGS 1

II INTRODUCTION 3

- A. Authority for this Report 3
- B. Purpose of the Study 3
- C. The Problem 4
- D. Approach to a Solution 5

III AN HISTORICAL PERSPECTIVE OF THE BAYLANDS 6

IV SPECIALIZED INTERESTS IN THE BAYLANDS 9

- A. Santa Clara County Flood Control and Water District 9
- B. Department of the Army, Corps of Engineers 10
- C. San Francisco Bay Conservation and Development Commission (BCDC) 12
- D. California Regional Water Quality Control Board, San Francisco Bay Region 15
- E. California State Lands Commission 16
- F. United States Geological Survey (USGS) 17

V LOCAL PLANNING AND POLICIES 18

- A. Baylands Subcommittee, Planning Policy Committee 18
- B. City of Palo Alto 20
- C. City of Mountain View 22
- D. Moffett Naval Air Station and Ames Research Center 23
- E. City of Sunnyvale 23
- F. City of Santa Clara 25
- G. City of San Jose 25
- H. City of Milpitas 26
- I. Leslie Salt Company 27
- J. Santa Clara County 28
  - 1. Department of Public Works 29
  - 2. Parks and Recreation Department 29

V LOCAL PLANNING AND POLICIES continued

3. Zoning 29
K. National Wildlife Refuge 30

VI POPULATION AND LAND USE 32

A. Population and Employment 32
1. Population Growth in Santa Clara County 1900–1970 32
2. Employment in Santa Clara County from 1940 to 1969 34
3. Projected Population Growth to 2020 34
4. Projected Employment to 2020 37
B. Land Use Aspects of Population and Population Growth 38
1. Land Use Projections 40
2. Location of Industrial Land 40
3. Location of Available Land 43
4. Land Use in the Baylands Study Area 44

VII ECOLOGY 47

A. The Ecological Inventory 47
1. Tidal Flats 47
a. Westside Flats Open to Bay 48
b. Estuarine Flats 49
c. Tidal Slough Flats 49
2. Salt Marshes 49
a. Salicornia Tidal Marsh 50
b. Tidal Slough Eyebrows 52
3. Salt Ponds 53
a. Salt Pond Levees 58
4. "Uplands" 59
a. New Chicago and Similar Wastelands 60
b. Sanitary Fill Sites 61
c. Streamside Levees and Banks 62
d. Upland Flood Plains 63
5. Open Water 63
B. Comparative Evaluation Summary 66
C. Recreational Uses and Constraints 67

VIII GEOLOGY, SOILS, AND SEISMICITY 70

A. Geologic and Soil Conditions 70

VIII GEOLOGY, SOILS, AND SEISMICITY continued

1. Alluvium and Bay Mud 71
2. Bedrock Features 71
3. Soils 72
4. Subsidence 72
5. Typical Subsurface Profiles 73
6. Use of the Profiles in Establishing Geologic Risk Zones 74
7. Geologic Risk Zones 75
8. Lateral Spreading 77
9. Liquefaction 78

B. Seismicity 79
1. Historic Activity 81
2. Maximum Probable and Maximum Credible Earthquakes 82
3. Proximity of Surface Faulting 84
4. Earthquake Recurrence 85
5. Earthquake Effects 85
    a. Ground Motions 85
    b. Liquefacton Potential 85
    c. Levee Stability 86

C. Summary 86

IX ALTERNATIVE PLANS AND DESIGN CRITERIA 88

A. Description of Alternative Plans 88
1. Do-Nothing Plan 88
    a. Appraisal of Existing Levees 88
    b. Storm Drainage 89
2. Inboard Levee Plan 90
3. Inboard Levee Plan with Channel Levees 92
4. Outboard Levee Plan 92
5. Outfall Channel Levee Plan 93

B. Design Criteria and Considerations 93
1. Design Parameters 94
    a. Fresh Water Flooding 94
    b. Salt Water Flooding 94
    c. Tides 95
    d. Wave Action 95
        (1) Outboard Levees 96
        (2) Inboard Levees 97
        (3) Data Collection 98
    e. Freeboard Requirements 99

IX ALTERNATIVE PLANS AND DESIGN CRITERIA continued

f. Earthquake Effects 99
g. Subsidence 99
h. Settlement 100
i. Ground Water Seepage and Uplift 100
2. Levee Design 101
a. Crest Height Determinations 101
b. Cross Section Materials 102
c. Side Slopes and Crest Widths 102
d. Types of Levee Construction Considered 102
(1) Dredged Bay Mud 103
(2) Compacted Imported Fill 104
(3) Steel Sheet Pile Cellular Cofferdam 105
(4) Sanitary Land Fill 106
e. Recommended Levee Section 107
f. Characteristics of Recommended Construction Materials 107
3. Internal Drainage Design 108
a. Drainage Systems Considered 108
b. Drainage Facilities for Alviso 109
c. Drainage Facilities for Outlying Salt Ponds 109
d. Impact of Alternative Plans on Drainage 109
(1) Do-Nothing Plan 110
(2) Inboard Levee Plan and Inboard Levee Plan with Channel Levees 110
(3) Outboard Levee Plan 110
4. Channel Outfall Considerations 110
a. Backwater Profile Analyses 110
b. Evaluation of Channel Outfall Alternatives 111
(1) Combining Tributary Channels into Main Channel Outfalls 111
(2) Channel Diversion into Tidegated Flood Retention Basins 112
c. Sedimentation 112

X CONSTRUCTION, OPERATION AND MAINTENANCE COSTS 115

A. Method of Construction 115
B. Unit Prices 116
1. General 117
2. Levees 117
3. Drainage Systems and Structures 118
C. Construction Cost Index 120
1. General 120

X CONSTRUCTION, OPERATION AND MAINTENANCE COSTS continued

  2. Cost Trends 120
  3. Cost Index 120
D. Construction Cost Estimates 120
  1. General 120
  2. Elements of the Estimate 125
    a. Land and Right-of-Way 125
    b. Special Construction Features 125
    c. Engineering, District Overhead, and Contingencies 125
  3. Costs Not Included in the Estimate 126
    a. Roads, Utilities and Bridge Costs 126
    b. Escalation 126
E. Operation and Maintenance 126
  1. Levees 126
  2. Outfall Channels 127
  3. Pumping Stations 129
F. Cost of Do-Nothing Alternative 129
G. Comparative Summary of Costs 130

XI ECONOMIC COSTS AND BENEFITS, AND PROJECT FINANCING 131

A. Classification of Lands in the Study Area 131
B. Value of Lands and Improvements Protected by Alternative Plans 131
C. Overall Long-Term Economic Benefits to the County 139
D. Net Socio-Economic Benefit 139
E. Costs and Lands Protected Under Plans 140
  1. Inboard Levee System 141
  2. Outboard Levee System 143
  3. Inboard Levee System with Outfall Channel Levees 145
  4. Allocation of Costs to Protected Lands and to the District 147
  5. Cost Allocation and the Inboard System with Outfall Channel Levees 147
  6. Cost Allocation and the Outboard Levee Plan 148
  7. Alternative Concepts of District Responsibility 149
F. Alternative Methods of Financing 150

XII FINDINGS 152

A. Findings 152

APPENDICES

A. Bibliography 157
B. Tidal Heights
C. Climatic Effects of Alternative Levee Systems
D. Sedimentation in South San Francisco Bay Below Dumbarton Bridge

(Appendices B, C, and D are not included in this report, but are on file at the Santa Clara County Flood Control and Water District.)

TABLES

1. Limits of Navigability for Santa Clara County Sloughs and Tributaries 11

2. Population Growth in the United States, in California, in the San Francisco Bay Area, and in Santa Clara County, 1900 to 1970 33

3. Average Annual Employment in Santa Clara County in Selected Years, 1940 to 1969 35

4. Projected Population Growth in the United States, in California, in the San Francisco Bay Area, and in Santa Clara County, 1970 to 2020 36

5. Average Annual Employment in Santa Clara County Projected by Major Classes by Decades to 2020 38

6. Land Use by Major Categories in 1967, Santa Clara County 39

7. Land Use in Santa Clara County Projected to 2020 by Major Categories of Assessed Lands 41

8. Location of Industrial Land Use in Santa Clara County in 1967 42

9. Location of Available Lands in Santa Clara County in 1967 by Type 43

10. 1967 Land Use in the Study Area, by Major Classes, Below the 6.5-Foot Contour 45

11. Land Use in the Baylands Study Area, Compared With Countywide Land Use, By Classification, 1967 46

12. Geologic Risk Zones Established by Subsurface Conditions in the Baylands of Santa Clara County 76

13. Possible Design Earthquakes 80

14. Strong Earthquakes Reported in the San Francisco Bay Area and Influencing the Baylands Study Area 83

15. Location and Capacity of Major Drainage Area Pumping Facilities 91

16. Unit Prices Used to Determine Construction Costs of Levees 117

17. Additional Pumping Facilities and Costs Anticipated to Serve the Baylands Study Area 119

18. Summary of Construction Costs, Inboard Levee Plan 121

19. Summary of Construction Costs, Outboard Levee Plan 122

20. Summary of Construction Costs, Inboard Levee Plan with Channel Levees 123

21. Summary of Construction Costs, Outfall Channel Levee Plan 124

22. Summary of Annual Operation and Maintenance Costs, Inboard Levee Plan and Outboard Levee Plan 128

23. Distribution of Study Area Lands Above Inboard Levee, Between Inboard and Outboard Levees, and Beyond Outboard Levee 132

24. Acres and Values, Assessed and Market, of Lands Between the 6.5-Foot Contour and the Inboard Levee Plan 134

25. Acres and Values, Assessed and Market, of Lands Between the Inboard and Outboard Levee Plans 135

26. Acres and Values, Assessed and Market, of Lands Between the Outboard Levee Plan and the 6.5-Foot Contour Line 136

27. Acres and Values, Assessed and Market, of Lands and Water Areas Beyond the Outboard Levee Plan 137

28. Capital and Operational Costs, Inboard Levee Plan, Compared with 1971 Assessed Values, by Levees and Protected Land Areas 142

29. Capital and Operational Costs, Outboard Levee System, Compared With 1971 Assessed Valued, By Levees and Protected Areas 144

30. Capital and Operational Costs, Inboard Levee System with Outfall Channel Levees, Compared With 1971 Assessed Values, by Levees and Protected Areas 146

PLATES

1. Location of the Santa Clara County Baylands Study Area
2. General Area Subject to Salt Water Flooding If Levees Are Breached
3. Flood Control Zones
4. Incorporated Areas and Areas of Influence
6. Typical Slough-Salt Pond Levee Cross-Section
6. Generalized Map of Salt Ponds
7. Cross-Section of Salt Pond Levee Showing Effect of Salt Spray on Vegetation
8. Cross-Section of Stevens Creek - Pond 2 Levee Showing Varied Growth on Stable Site with Low Salinity
9. Estimated Thickness of Bay Mud
10. Contours of Bedrock Surface
11. Lines of Equal Land Surface Subsidence, 1934–1967
12. Typical Subsurface Profiles
13. Risk Zones Assigned to Individual Water Wells and Boring Logs
14. Geologic Risk Zones Based on Soil Conditions
15. Historic Fault Displacement Near the Baylands
16. Position of Baylands Relative to Active Faults
17. Estimated Ground Surface Acceleration Due to Earthquakes
18. Existing Levees and Responsible Agencies
19. Drainage Areas and Existing and Proposed Pumping Stations
20. Inboard Levee Plan
21. Inboard Levee Plan With Channel Levees
22. Outboard Levee Plan
23. Typical Section, Outboard Levee and Inboard Levee
24. Backwater Curves of Alviso Slough-Guadalupe River
25. Census Tracts in the Baylands
26. Sub-Areas and Acreages in the Baylands
27. Tide Level Diagram, Mouth of Alviso Slough

PHOTOGRAPHS

Aerial View of Santa Clara County Baylands, looking west, (by USGS). Frontispiece

Alviso, July 1971 and February 1963, (by Santa Clara County Flood Control and Water District). Following page 3

South Bay Yacht Club, Alviso, 1914, (by San Jose Historical Society,) and South Bay Yacht Club, Alviso, 1972, (by Santa Clara County Flood Control and Water District). Following page 73

CHAPTER I

SUMMARY OF FINDINGS

The Baylands of Santa Clara County are subject to salt water flooding caused by high tides and wind-driven Bay waters overtopping existing levees. This problem has been intensified over the past 60 years by the subsidence of the low-lying Baylands.

Most of the existing levees were established solely to maintain the system of salt ponds situated on former marshlands. They do not provide a full measure of protection from salt water flooding to the study area.

A number of agencies have been invested with planning and regulatory controls over the use of portions of the Baylands, including the salt ponds. These include the San Francisco Bay Conservation and Development Commission and the Army Corps of Engineers.

The Planning Policy Committee of Santa Clara County has adopted a policy plan which recommends that levee improvements be made only where needed to protect drylands appropriate for urban development.

A National Wildlife Refuge has been approved by Congress and the President which includes all of the salt pond area in the Santa Clara County Baylands east of Alviso Slough.

Future demands of land in Santa Clara County for urban purposes can be met by the use of lands available elsewhere in the County without requiring the reclamation or redevelopment of the wetlands in the Baylands study area.

The ecology of the undeveloped portion of the Baylands is of special significance. The most important segments are the tidal mudflats and tidal sloughs which shelter and nourish a great variety of aquatic animals, wildfowl, waterbirds, and marshland animals.

The two principal geological hazards in the Baylands are lateral spreading of soil layers and liquefaction of underlying soil layers. Both conditions can be induced by earthquake shaking. The Baylands area lies between active fault systems in one of the most seismically active areas in the United States.

Five alternative protective systems were analyzed in this study. The first was the existing system which is deemed inadequate to provide protection at the level of standards developed for this study. The second is an inboard levee system, 34 miles long, following the alignment of the existing most inboard levees. The third is an inboard levee system with outfall channel levees, which provides fresh water protection to the salt ponds, and is 59 miles in length. The fourth is an outboard levee system which is located along the existing outboard levees on the Bay side of the salt ponds and is 60 miles in length. The fifth is an outfall channel levee plan, 45 miles in length, which provides fresh water protection only along the full length of such channels.

The total construction costs estimated for the alternatives are:

Inboard Levee Plan	$ 57,720,000
Outfall Channel Levee Plan	68,160,000
Outboard Levee Plan	93,840,000
Inboard Levee Plan with Channel Levees	95,440,000
Do-Nothing Alternative	160,456,000

Annual operation and maintenance costs for the two basic alternatives are estimated as follows:

Inboard Levee Plan	$ 369,700
Outboard Levee Plan	1,005,000

The present assessed value of lands protected by the Inboard Levee Plan is $40,114,000, averaging $6,212 per acre. The assessed value of lands protected by the Outboard Levee Plan is $43,463,000, averaging $4,154 per acre. The value of the additional land protected by the Outboard Levee Plan is less than one-sixth as much per acre as the lands protected by the Inboard Levee Plan. If the costs of the two basic alternative plans were borne by the four flood control zones whose watersheds drain into the Bay through the Baylands, the annual average tax rate per $100 of assessed value would be about 14 cents for the Inboard Levee Plan and 23 cents for the Outboard Plan. If the costs were borne solely by the lands directly benefitted, the annual average tax rate per $100 of assessed value would be about $10.35 for the Inboard Levee Plan and $15.48 for the Outboard Levee Plan.

II INTRODUCTION

One of the great inland seas of the world is San Francisco Bay, a secluded inlet of the Pacific Ocean covering more than 400 square miles and holding two trillion gallons of salt water. Nine counties and more than thirty cities rim its shores. It harbors the trading ships and planes of the world and the fishing and pleasure boats of the region. It provides facilities along its shores for intensive industrial activities and for neighborhoods of shoreline homes and apartments. In some places, it still provides sheltered tidal flats and marshes and an intricate food web which nourishes a great variety of aquatic animals, wildfowl, waterbirds and marshland animals constituting a unique metropolitan area wildlife resource.

One of the nine counties fronting on the Bay is Santa Clara County, which is situated at its shallow southern end. Within the County there has been established a Flood Control and Water District charged with the responsibility of planning for and providing facilities for the protection of life and property within the District from damage from flood and storm waters.

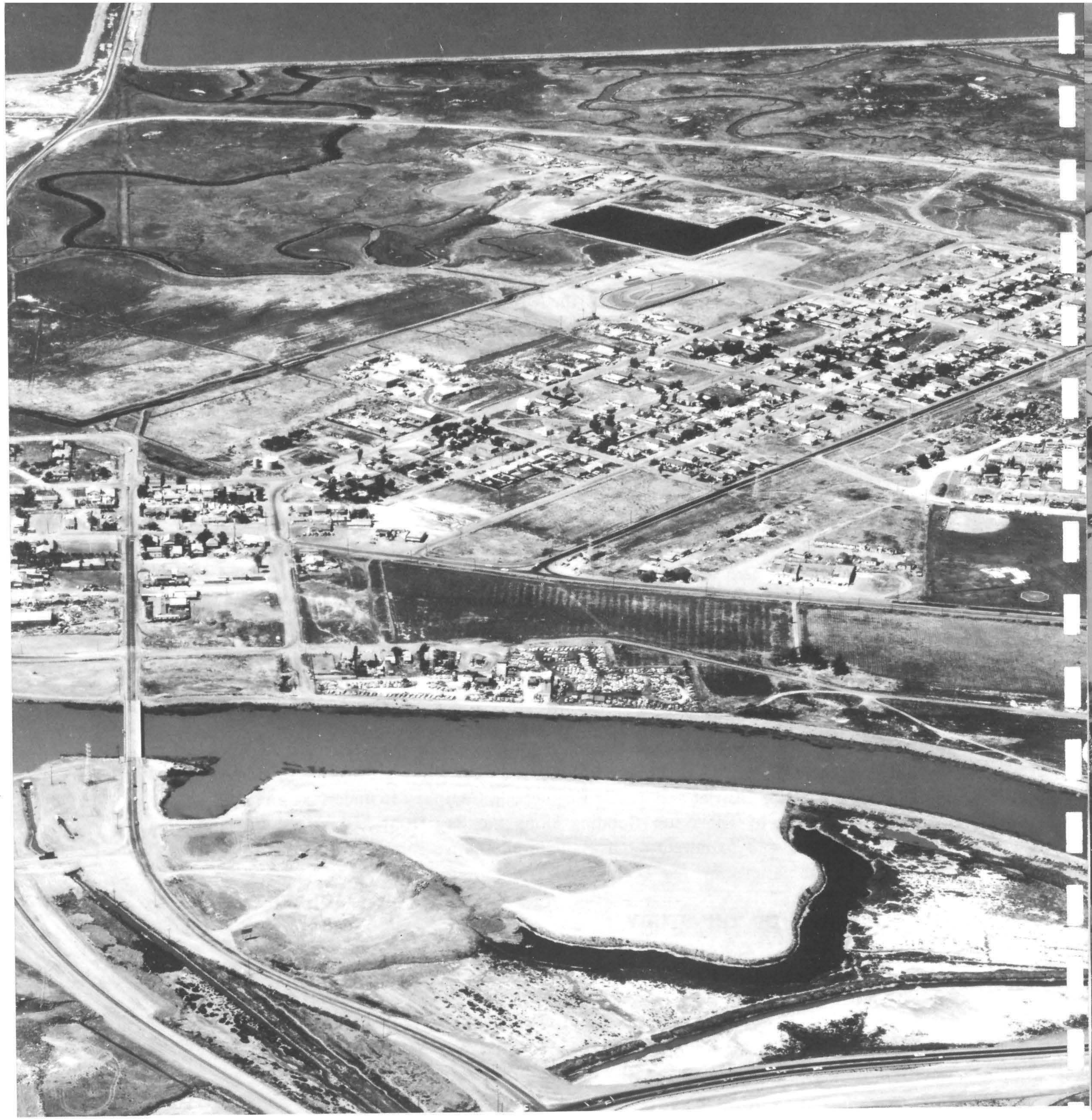
A. AUTHORITY FOR THIS REPORT

The authority for this report, and the study which it describes, is derived from a contract entered into on June 8, 1971 by and between the Santa Clara County Flood Control and Water District and Tudor Engineering Company to undertake a planning study of the problems of salt water flooding along the Bay front and in the Baylands area of the District, and to develop and evaluate alternative solutions to serve as a basis for policy determinations by the District.

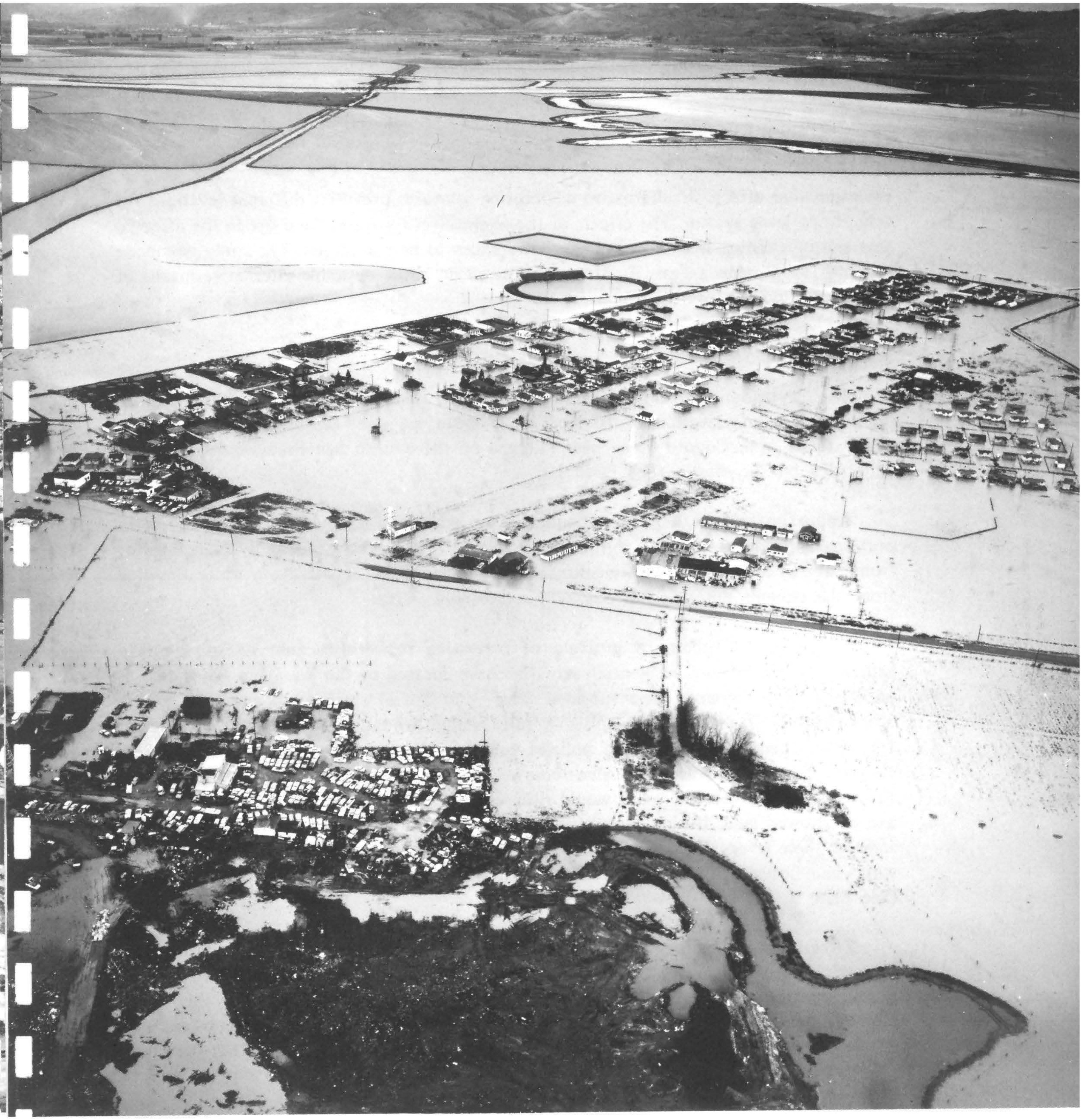
B. PURPOSE OF THE STUDY

The basic flood problems presently handled by the Santa Clara County Flood Control and Water District are caused by fresh water flowing in the major streams of the County from near their headwaters to their outfalls into San Francisco Bay. Consideration of salt water flooding has been given only where the Bay waters back up into some of the fresh water outfall channels of the major streams.

The purpose of this study has been to develop information that will assist in a determination of whether the Flood Control and Water District should expand its responsibilities to include protection of the areas between the outfall channels from salt water flooding, and if so, how this may best be accomplished. All factors pertinent to the present flooding problems and their potential solutions in the area adjacent to the Bay in Santa Clara County were to be considered, including the social, economic and



Alviso, July 1971



Alviso, February 1963

The problem of flooding is ever present in the Baylands because of the low topography and the unknown stability of the perimeter levee system.

environmental effects of alternative engineering solutions providing different locations for a Bayfront levee system. The effects of the alternatives on future land use in the affected area and on existing fresh water channels were also to be considered. The study was made in order to provide a basis for the selection of the most desirable alternative means of salt water flooding protection.

C. THE PROBLEM

The Baylands study area as defined consists of that portion of Santa Clara County lying between an elevation of 10 feet above mean sea level (MSL) and the shoreline, and extends from Coyote Creek near Milpitas on the east to San Francisquito Creek in Palo Alto on the west. (See Plate 1.)

Approximately 14,000 acres of this area are subject to salt water flooding, and some portions are subject to both salt water flooding from the Bay caused by high tides or from streams affected by the tides under storm conditions, and to fresh water flooding from the streams entering the Bay within the study area.

Flooding has become a problem of increasing concern because intensive utility, military, industrial and residential activities have located in the low-lying Baylands. In addition, these Baylands have subsided from 3 to 7 feet since 1934 and may subside approximately 2 feet further unless a fully stable groundwater level can be attained through recharge and extraction policies and regulations currently in force. Much of the land in the study area has been removed from tidal action by dikes and levees built to enclose salt ponds on what would otherwise be submerged land, tideland, or swamp and overflowed land. During periods of excessive freshwater runoff, flooding occurs behind some of these levees. Were the levees to be breached under conditions of high tide, strong winds and heavy rainfall, most of the Baylands would be subject to salt water flooding. (See Plate 2.)

Effective flood control planning is dependent upon firm decisions as to the location of areas in the Baylands which will be developed for intensive urbanized uses requiring protection from hazards to life and property caused by flooding. On the other hand, effective land use planning is dependent upon a knowledge of the costs and consequences of developing and protecting lands susceptible to flooding compared with the costs and consequences of retaining lands in, or returning lands to, their natural state subject to wet and dry cycles caused by tidal movements.

The problem of flooding is the single most important consideration in land use planning in the Baylands. It is an omnipresent problem because of the low topography of much of the Baylands and the unknown stability of the perimeter levee system. Land use policies, however, are still less than certain in portions of the Baylands. Two conditions prevail in the study area: in some locations, existing land use policy virtually dictates the direction for flood control measures, and in other portions of the area the feasibility or desirability of flood control measures may define or substantially assist in defining the ultimate land use policy.

D. APPROACH TO A SOLUTION

In order to assess fully the many interacting ramifications of the study problem and to formulate recommendations for a solution, Tudor Engineering Company, Consulting Engineers and Planners, assembled an interdisciplinary study team consisting of the following:

Economist:	Dr. Andrew H. Trice
Geologist and Soils Engineer:	Woodward-Lundgren & Associates
Hydrologist:	Hydrocomp International
Ecologist:	Philip H. Arend, Wildlife Associates
Supporting Engineer:	Mark Thomas & Company, Inc.

In addition, advisory assistance was rendered on climatology by Dr. Mario Giovinetto, Associate Professor, Department of Geography, University of California, Berkeley; on tidal hydraulics by Dr. James A. Harder, Associate Professor, Department of Civil Engineering, University of California, Berkeley; on sedimentation by Dr. Ray B. Krone, Chairman, Department of Civil Engineering, University of California, Davis; and on marine ecology by Dr. Joel F. Gustafson, Professor of Biology, San Francisco State College.

A general reconnaissance of the Baylands study area was made by the team at the outset of the study and a basic inventory was made of past studies, of existing data and of opinions or positions formed by technical and political groups concerned with or affected by the study. This was followed by interviews by various team members with numerous public agencies and private interest groups. These interviews were recorded in a series of memoranda which were circulated among all team members. A set of aerial maps containing elevation data, flown in April 1971, were provided by the Flood Control and Water District.

Each team resource specialist then analyzed the study area from his particular point of view and in the light of the several alternative possible plans which might contribute to the solution of the salt water flooding problem. The results of these analyses and the findings are described in the chapters which follow. In addition to its substantive inputs, Tudor coordinated the activities of the team and is responsible for the final findings and for this report.

III. AN HISTORICAL PERSPECTIVE OF THE BAYLANDS

The Baylands study area is an ecologically fragile area that has undergone dynamic structural and environmental change over the past 100 years. The prehistoric broad salt marshes dissected by the meandering brackish tidal sloughs of Coyote, Alviso, Guadalupe and other, lesser, drainages have long been trapped behind earth levees and shaped by dredger and bulldozer. Much of the tidal grasslands and the flood plains have disappeared. They were modified first to stock pasturage and hay farms, then to truck gardens and orchards, and most recently to factory and business sites, suburban housing, military installations and aero-space industries, ringed by a complex of teeming freeways. The tidal salt marshes, where the bright green pickleweed flats once provided miles of sanctuary for shorebirds and waterfowl, have been bound within the leveed basins of evaporation ponds where solar heat and drying winds change the trapped water from salt brine to mountains of white salt.

Today only fragments remain of the Baylands as they existed in January 1777, when the Spanish padres founded Mission Santa Clara de Asis alongside the Rio Guadalupe. The padres set out the first of the famed Santa Clara Valley orchards and they found that, besides abundant water in the river, many springs existed for irrigating the fields. The "abundant" water forced the mission to move within a few years - the river seasonally overflowed - and a second church, on higher ground, was twice destroyed by earthquakes, in 1812 and 1818. A third church lasted until 1865. Of this, a remnant of adobe cloisters can still be seen in a garden at Santa Clara University.

Closely associated with the early history of the Baylands as well as with Mission Santa Clara, is Alviso, located at the head of Alviso Slough. Ignacio Alviso, mayordomo at Mission Santa Clara, settled there in 1840 and his name became attached to the community which then served as El Embarcadero de Santa Clara, a shipping point for the hide trade. Large boats or launches, manned by the Olhone Indians, lightered the cattle hides to the trading vessels. As trade in this shipping port increased with the 1849 gold rush, a steamer line from San Francisco was established, with a one-way fare of $35.00 plus a $10.00 stage fare to San Jose. After 1865 and the coming of the railroads, Alviso's brief flame of economic importance guttered. Today, a small craft recreational boating harbor serves to remind of Alviso's relation to the Bay, and three small custom boat works exist. Little remains of the vast tidal marshes that once adjoined this waterfront village: the marshlands are now almost entirely enclosed by saltpond levees.

Over the years, Alviso has also served as a departure point for duck hunts in the local sloughs and marshes. Some of this recreation still is carried on, predominantly by hunting-access lessees of the Leslie salt ponds or by members of privately owned duck clubs. There is comparatively little public hunting and there are no State-operated waterfowling lands in South San Francisco Bay such as those that exist in the North Bay or in the Sacramento-San Joaquin Valley.

The dominating urban center whose limits extend into the Baylands is the City of San Jose, founded in November 1777 as El Pueblo de San Jose de Guadalupe, the first agricultural town established in Alta California. As with Mission Santa Clara, the first homes of the settlers had to be moved to high ground above the Rio Guadalupe flood plain. The cattle pastures and grain farming of the first seventy-five years of the area's development began to give way after the American Civil War to fruit farming, an activity that created the largest cannery and dried fruit packing center in the world prior to World War II. Concomitant with this development there were serious environmental impacts on the Baylands. Water tables in Santa Clara Valley began to fall, and land subsidence and increased salt water intrusion became severe. The dwindling water flows in the drainage streams had to transport ever more cannery waste; the streams became polluted and the anadromous fish runs were irretrievably lost.

The Bayfront cities of Palo Alto, Mountain View, and Sunnyvale have each played their role in the environmental history of the Baylands, although the adverse impacts have been somewhat less severe on their Bayfront lands than on those at the extreme southern reach of the Bay. Salt water intrusion, land subsidence, falling water tables, and destructive floods have been less severe than those in the flood plains of Coyote Creek, Alviso Slough and Guadalupe Slough. These northernmost of the Santa Clara County Bayfront communities were not settled until the middle or late 19th century and remained only modestly industrialized until after World War II. Palo Alto, known for Stanford University, developed like many other Peninsula cities as a bedroom community for San Francisco commuters.

Mountain View, before the railroad reached it in 1864, was known principally for the Mountain View House, a main stop of the four-horse Concord coaches on the San Francisco-San Jose stage line. The original village of Sunnyvale, once the seat of '49 pioneer Martin Murphy's Rancho Pastoria de las Borregas, developed as a quiet trade center for local ranchers. Local orchards and truck gardens led to the establishment of canneries and packing plants in these towns and spurred their residential boom. Moffett Field, a military air base, was built after World War I on the Baylands between these two towns. Moffett Field became particularly renowned as the home port for the ill-fated dirigibles Akron and Macon. The immense hangars built to house these lighter-than-air craft still dominate the Baylands panorama. Other air and aerospace research and development centers now adjoin the U.S. Naval Air Station at Moffett Field. In all, nearly 3,000 acres of one-time mud flats, tidal marshes and flood plains of the Baylands have become developed for military and industrial uses.

The major direct impact on the Baylands during the past seventy-five years, and the one that has modified the Baylands environment most drastically, was brought about by the development of the salt industry. From the earliest days, crude solar evaporation ponds were built to harvest sea salt. By the turn of the century, much of the tidal marshlands of South San Francisco Bay had been enclosed behind the levees of a host of small salt-producing companies. After World War I, Leslie Salt Company, based in Newark, Alameda County, began its phenomenal growth and became one of the largest landowners in the San Francisco Bay Region. Many already existing solar evaporation pond systems were absorbed in toto and incorporated into a single but larger series of brine transport ponds serving Leslie. At present, in the Santa Clara County Baylands, salt water eventually destined for salt harvest in the Newark collecting ponds in Alameda County initially enters the system from Charleston Slough just south of Palo Alto. The water then passes through what had been the ponds of three minor South Bay companies. To avoid over-concentration and to permit the full advantage of gravity flow, additional sea water is taken into the system between the Stevens Creek outfall and the mouth of Guadalupe Slough, and again east of Alviso Slough. The brine is siphoned past Coyote Creek and Mowry Slough, and moved north to Newark.

The preliminary map of "Historic Margins of Marshland, San Francisco Bay, California," published by the United States Geological Survey in 1971, shows an extensive system of marshlands and sloughs where the salt ponds, garbage fills, and more intensive uses are now situated, and graphically illustrates the inroads made on the Baylands since the first Europeans arrived in 1769. But it must be recognized that modification by man of a "natural" environment is an integral part of man's own ecology. Man, like any other organism, interacts with his environment. An environmental impact occurs, organisms react and interact; some individuals or species are affected adversely, while other individuals or species, or even whole groups of species, may benefit. In the Baylands, the impacts that eradicted acres of pickleweed and the animals dependent on pickleweed, have favored brine flies and brine shrimp, and the shorebirds and others who forage on these brine invertebrates.

Ecosystems, such as those in the Baylands, must be regarded as dynamic assemblages of living and non-living bits of physical matter under continual stress and tension; all environments must ever experience change. Despite his most intensive efforts, man can never prevent this dynamic change: at best, he can but modify or guide the impact and direct the change so as to ensure his own desired goals. To guide future impacts toward desired goals the environment should be inventoried, changes that have occurred should be evaluated, and an attempt should be made to foresee the results of directed changes and alternative options. This, in terms of salt water flood control in the Baylands, has been a function, in part, of this study.

CHAPTER IV

SPECIALIZED INTERESTS IN THE BAYLANDS

Besides the specific jurisdiction maintained over portions of the Baylands by individual cities and by Santa Clara County, one special district and a number of regional, state and federal agencies have interests or jurisdictions over one or another phase of activity in the Baylands which is pertinent to this salt water flood control study. A description of the special district and the agencies whose role is most important to the Baylands from the point of view of this study is presented in this chapter.

A. SANTA CLARA COUNTY FLOOD CONTROL AND WATER DISTRICT

The Santa Clara County Flood Control and Water District was created in March 1968 through consolidation of the Santa Clara Valley Water Conservation District which was formed in 1929, and the Santa Clara County Flood Control and Water District which was formed in 1951. The jurisdiction of the District is county-wide. It is organized under a Board of Directors consisting of seven members, of whom five are each elected from one of the five County Supervisorial Districts. The other two members serve at large and are appointed by the Board of Supervisors from the northern and southern sections of the County. In addition to the appointment of two members, the only other authority of the Board of Supervisors over the District is its power to review and approve its annual budget.

The District has responsibility for the reduction of flood hazards for all of Santa Clara County, which it carries out through a program of construction, operation, and maintenance of water-retention or -confining facilities such as reservoirs and dams, levees, and stream and outfall channel improvements, and through a program of controlling and regulating groundwater extraction and of recharging groundwater basins in order to reduce and ultimately to stop the subsidence of lands within its area of jurisdiction. The District is divided into five watershed zones, of which four border on the Bay. (See Plate 3.)

The flood control responsibilities of the District have been considered to apply to the major streams of the county, from near their headwaters to their outfalls into San Francisco Bay or to the District boundaries. Flooding from water developed on a particular site or from a small drainage basin is considered to be a local drainage problem and is the responsibility of the city in which the site is located, or of the County, through its Public Works Department, if the site is in an unincorporated area. The District does not have the authority to approve or disapprove the internal drainage design of subdivisions, but it reviews and comments on subdivision plans submitted to it for this purpose by cities or the County.

The basic flood problems that have been handled to date by the District are from fresh water, with consideration of salt water flooding having been given only where salt water backs up from the Bay into the freshwater outfall channels of the major streams. In its conduct of this basic responsibility in the Baylands, and of possible extended salt-water flood protection measures, the District must coordinate with or submit to other federal, state, and regional agencies, in addition to county agencies which are legally vested with authority and responsibility in the area. The most important of these agencies, and their functions and policies, are described in the remainder of this chapter.

B. DEPARTMENT OF THE ARMY, CORPS OF ENGINEERS

The Department of the Army, acting through the San Francisco District of the Corps of Engineers, performs extensive civil functions which include the execution, operation, maintenance and control of authorized river and harbor and flood-control improvements, and the administration of certain laws enacted by Congress for the protection and preservation of navigation and navigable waters.

One of the principal laws under which the Corps functions is the River and Harbor Act of 1899, which gives it jurisdiction over all improvements, construction, dredging and discharges into navigable waters, including the location and plans of dams and dikes, and the issuance of permits for excavation or fill in navigable waters. Recent acts of Congress have shifted the Corps' concern from the simple protection of navigation capability to broader aspects of protection, including environmental quality with special emphasis on water quality. Natural storm-runoff waters do not come under the jurisdiction of the Corps but maintenance, dredging and construction projects associated with flood protection do.

The Corps defines the boundary of navigable waters as mean higher high water (MHHW). This is a changing definition, as it follows new encroachments of the tide wherever they occur. The boundaries are not mapped, but are determined on a case-by-case basis. Limits of navigability were most recently determined for several South San Francisco Bay waterways on August 1, 1971 by the Corps for its general guidance. Those within the Santa Clara County Baylands study area are listed in Table 1.

In addition to navigable waters, the San Francisco District office of the Corps announced in January, 1972 that it is now exercising its regulatory authorities "within the area bound by the plane of the mean of the higher high water" and that permits are required for all new work in unfilled portions of the interior of diked areas situated at a level below former mean higher high water.

Permits are issued by the Corps for minor work or projects in which there will be no navigational or environmental impairment and no public opposition. In all other cases public notice is given to an extensive number of agencies. Usually, public hearings are

TABLE I

LIMITS OF NAVIGABILITY FOR SANTA CLARA COUNTY SLOUGHS AND TRIBUTARIES

(Determined by the Department of the Army, Corps of Engineers)
August 2, 1971

Waterways	Limits of Navigability
Alviso Slough-Guadalupe River	Campen Avenue
Charleston Slough	Baywardmost dike
Coyote Creek	
Main branch	Milpitas sewage plant
South branch	0.5 mile west of San Jose-Santa Clara sewage plant
Southeast branch	0.5 mile southwest of Fremont Airport
Guadalupe Slough	0.9 mile north of Highway 237 interchange
Mayfield Slough	0.1 mile west of north-south dike (interpreted as the current basin of the Palo Alto Yacht Harbor)
Mountain View Slough	Sewage disposal works
San Francisquito Creek	Undetermined

N. B. Stevens Creek is not defined as navigable.

not opened by the Corps, since most controversial projects receive a public hearing at other stages of governmental review prior to Corps action, although the Corps may open new hearings if it chooses. Conflicts between any public or private party and the permit applicant are ordinarily handled through the arrangement by the Corps of direct communications between the conflicting parties.

Certain federal or state agencies require specific information prior to recommending issuance of a permit by the Corps. In cases of dredging, the Environmental Protection Agency may require detailed laboratory analysis of the sediments to be dredged, to insure that no harmful substances are released into open waters during the project.In accordance with the Federal Water Quality Improvement Act of 1970, a certification is required from the California Water Resources Control Board stating that there is reasonable assurance that the work will be conducted in a manner which will not violate applicable water quality standards. The State Board may also require a laboratory analysis of the material to be dredged.

The regional office of the Bureau of Sport Fisheries and Wildlife, Department of Interior, is consulted by the Corps for a review and report on the impacts on fish and wildlife in a proposed project area. Coordination with the various departments of state government is accomplished through the State Resources Agency. One of its important components is the San Francisco Bay Conservation and Development Commission (BCDC). The Corps generally will not issue a permit if BCDC approval is not obtained.

Although environmental impact statements technically are not required for Corps permits, they tend to expedite permit processing and in some cases are required by other agencies of federal or state government involved in the Corps' evaluation process. Such statements generally consist of descriptions of estimated alterations to existing water, air or land resources, the possible adverse effects of such alterations, and the alternatives to the proposed action.

Two studies are programmed by the Corps which will provide information for regional planning in the Bay. The first is an "In-Depth Study" of regional navigation potential, including a commodity-flow study utilizing world-wide data, which will have a significant bearing on future South Bay navigational development decisions. The second is a Water Quality and Waste Disposal Study, conducted independently of related studies by the State. In addition, it is programming a new study and reevaluation of the Guadalupe River.

C. SAN FRANCISCO BAY CONSERVATION AND DEVELOPMENT COMMISSION (BCDC)

The San Francisco Bay Conservation and Development Commission was created by the Legislature in 1965 and was continued in existence by the Legislature in 1969. It is administratively within the State Resources Agency and is directed by law to plan for the use of the Bay and to regulate filling, extraction,and changes in the use of the Bay and its shoreline. It has two major objectives: to protect the Bay as a great national resource for the benefit of present and future generations; and to develop the Bay and its shoreline to their highest potential with a minimum of Bay filling.

Its jurisdiction extends over three categories of land and water:

1. The regulation of filling and dredging in all water areas of the Bay that are subject to tidal action, including all sloughs and the marshlands lying between mean high tide and five feet above mean sea level;

2. A 100-foot wide band of land bordering the shoreline of the Bay, in which BCDC has the responsibility to require public access to the Bay to the maximum extent feasible and to insure that shoreline property suitable for high-priority water-related purposes is reserved for these purposes;

3. Salt ponds which have been diked off from the Bay for the making of salt by solar evaporation of bay water, and managed wetlands diked off from the Bay and used as duck hunting preserves, game refuges or for agriculture, in which the Commission is to encourage dedication or public purchase to retain water area, in the event of proposals for filling. If development of these areas is authorized, the Commission is to insure that public access to the Bay is provided and that the maximum amount of water surface is retained, consistent with the nature of the development.

In the Baylands of Santa Clara County the BCDC jurisdiction includes Coyote Creek to the easternmost point of Newby Island and nearly all of the floodable area up to the inboard edge of the salt ponds. Stevens Creek is excepted.

The Commission is required to adopt a plan and policies to guide development within the area of its jurisdiction and to regulate development through a permit system. The plan currently in effect is the *San Francisco Bay Plan,* adopted in 1969.

Two types of permit applications are reviewed by BCDC. Minor permits for small projects or routine dredging may be issued by the executive director. Work of larger scale or in which conflicts may be present are handled as major permits and are given staff review and public hearing before the 27-member Commission.

Reports on permit applications are received from the cities and counties involved, from the San Francisco Bay Regional Water Quality Control Board, and from other agencies of government which may be affected by the proposed work. Applications are often reviewed by the Commission's Engineering Criteria Review Board and Design Review Board.

Projects involving fill in the Bay waters must conform to Bay Plan policies and must demonstrate:

1. That public benefits from the fill exceed public detriment,

2. That there is no alternative upland site available for the project,

3. That the project is of a water-oriented nature,

4. That the fill is the minimum necessary to achieve the purpose of the project,

5. That harmful effects are minimized,

6. That public health, safety and welfare are protected,

7. That the fill will tend to establish a permanent shoreline, and

8. That valid title to the land is secured.

Projects involving work within the 100-foot shoreline band must demonstrate that maximum feasible public access is included and that the project is consistent with the Bay Plan.

The San Francisco Bay Plan contains several policies related to flood control in South San Francisco Bay. The flooding problem in this locale is specifically recognized and approval of development projects there is made contingent upon an adequate solution to the flooding, land subsidence and geologic risks from the viewpoint of public health, safety and general welfare.

The Plan seeks to maximize the surface area and volume of Bay waters, and states that proposals for fill, levees or piers are to be judged against their impact on water circulation. The protection of marshes and mud-flats is given high priority, and the multiple use of flood control channels and levees for recreation is emphasized.

The policy relating to the salt ponds emphasizes their continued operation in salt production as long as economically feasible, and states that, if development of the ponds or of wetlands is proposed, dedication or public purchase of some areas should be sought to maintain open waters.

Plan Maps 6 and 7 indicate various proposals in the Baylands of Santa Clara County and state the principal Plan objectives for the area to be (1) preservation of wildlife habitats, and (2) development of water-oriented recreational uses.

Certain areas of these maps are designated specifically for recreational use: The Palo Alto Baylands and the Mountain View Shoreline Park. These areas are referred to as "Priority-use areas" and were recently adopted as such in final form after public review. With the consent of the State Legislature, these priority-use areas will become legally restricted to the land uses designated in the Plan.

Based on the adopted San Francisco Bay Plan, the executive director of the BCDC made the following comments pertaining to the Baylands of Santa Clara County in a letter to the Santa Clara County Flood Control and Water District under date of November 15, 1971:

"Recent indications are that subsidence in the South Bay has been arrested; if it should continue in the future, however, extensive dikes may be needed to prevent tidal inundation of low-lying areas. Already, portions of Alviso are below mean sea level. To minimize the potential hazard to Bayside development from subsidence due to groundwater withdrawal, proposed development at the lower end of the South Bay should either be well above mean sea level or else adequately protected by dikes. Existing development should similarly be afforded protection from salt water inundation.

"The Bay Plan urges that eventually some or all of the salt ponds be acquired by the public and the dikes breached, to thereby enlarge the Bay. To best protect this option for the public, any strengthening of levees for flood control purposes (to protect the low-lying areas behind the salt ponds from inundation, especially in the event of a major earthquake breaching the present dikes) should be accomplished on the line of dikes *between the salt ponds and the land behind them,* rather than with dikes between the salt ponds and the Bay."

D. CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD, SAN FRANCISCO BAY REGION

The San Francisco Bay Regional Water Quality Control Board represents, at the local level, the water quality control authority of the State Water Resources Control Board. Both boards are administratively a part of the State Resources Agency.

The jurisdiction of the parent board includes all waters of the State, surface and underground, fresh and saline. This includes flood waters. The regional board, subject to review by the state board, is empowered to adopt regional plans for water quality control; to issue policy statements; to prescribe minimum requirements for the protection of beneficial water uses and the prevention of nuisance; to require other state or local agencies which handle water to make reasonable investigations and to report on technical factors involved in water quality control; and to cause the abatement of pollution through legal means. The boards also aid in allocating state financial assistance for water quality improvement.

The regional board comments on BCDC and Corps of Engineers permit applications and may recommend that permits include water quality conditions. The regional board has chosen to set water quality standards on a case-by-case basis rather than a region-wide basis. The board determines the beneficial uses of water to be protected as well as the existing land uses affected by water quality in a given area, and then sets water quality standards. These beneficial uses may include domestic, municipal, agricultural or industrial water supply; power generation; recreation; esthetic enjoyment; navigation; and preservation and enhancement of fish, wildlife and other aquatic resources or preserves.

While flood waters are included in the jurisdication of the regional board, very little regulation has been exercised in this regard. Only one case of flood water quality regulations has occurred in the Santa Clara County Baylands. This was in the City of Sunnyvale, where industrial wastes from private companies were being mixed with storm drainage which entered the Guadalupe Slough. The City was declared the discharger by the regional board and was asked to file a report. Discharge requirements were then set by the board and implemented by the City.

Standards for water turbidity and some biochemical properties of water are commonly set by the board for dredging projects. In cases of extensive dredging, the board may require laboratory analysis of sediments prior to commencement. In cases of sanitary land fill, leachate monitoring at the perimeter dikes may be required.

No general policies relating to flood or storm waters have yet been developed by the regional board. The Interim Water Quality Control Plan does not deal with flood waters but is concerned primarily with sewage treatment facilities.

E. CALIFORNIA STATE LANDS COMMISION

The majority of the Baylands owned by the State are administered by the State Lands Commission, composed of the Lieutenant Governor, the Controller, and the Director of Finance. The Commission's administrative staff is the State Lands Division of the Department of Conservation. The Commission is authorized to issue leases, permits and easements for the use of or extraction from State properties. Leases cover removal of shells, sand, gravel, mud, and oil and natural gas; and commercial, industrial, and commercial recreation installations. Permits are issued for small structures such as private piers and floats. Easements are granted for crossing under and over the Bay waters by pipelines, cables, and electric high tension lines.

The Santa Clara County Flood Control and Water District, by its enabling legislation, is granted the right-of-way for the location, construction and maintenance of flood control channels, ditches, waterways, conduits, canals, storm dikes, embankments, and protective works in, over and across public lands, including water areas, owned by the State which are not disposed of or in use, subject to a permit from the State Lands Commission.

Amendments to the California Public Resources Code adopted in 1970 now require an environmental impact statement for any proposed use of such State lands except recreational piers. The format for this statement calls for information on (1) quantified environmental impacts (changes), (2) unavoidable adverse environmental effects, (3) mitigation measures proposed to minimize the impact, (4) alternatives to the proposed project, (5) the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity, and (6) any irreversible environmental changes involved.

If rights-of-way are sought by the District over navigable waters owned by the State, other legal considerations may be introduced. A public trust for fishing, navigation and commerce is attached to State waters, but its applicability to varying situations has not been fully interpreted by the courts. In the past, removal of this public trust to permit closure to navigation has sometimes involved an act of the State Legislature.

F. UNITED STATES GEOLOGICAL SURVEY (USGS)

The United States Geological Survey (USGS), a part of the Department of the Interior, has its western office in Menlo Park, a few miles northwest of the Baylands study area. The San Francisco Bay Region was selected in 1970 for a unique three-year pilot study which is being undertaken cooperatively by the Department of Housing and Urban Development (HUD) and the USGS, and which is identified as the San Francisco Bay Region Environment and Resources Planning Study. The study was initiated in recognition of the fact that the urban sprawl that has engulfed the landscapes around U.S. cities since the end of World War II has been created with little regard for the natural assets of the landscapes, or for the hazards that attend their misuse.

The USGS has certain ongoing programs which are producing basic data pertinent to the study. The goal is to develop earth-science concepts, products, and procedures which can significantly improve regional planning and development. Additional data are to be gathered, and basic geologic, geophysical, hydrologic, and topographic data are to be translated into documents and maps that will be useful in the planning and decision-making process.

The study will delineate the natural physical features and processes that must be understood if urbanization and development in the Bay region are to proceed in a manner that will minimize disruption of those aspects of the environment that make the Bay region a desirable place to live; avoid unnecessary and uneconomic risks from geologic and hydrologic hazards, and detrimental interactions between natural processes and man's activities; and utilize the natural resources--both renewable and non-renewable--to the fullest extent compatible with development.

The work, scheduled for completion in fiscal 1973, is being reported in three numbered series of documents. One consists of Basic Data Contributions. Another consists of Technical Reports on the natural resources, and on the geologic and hydrologic features and processes that are of environmental concern. The third will consist of Interpretive Studies which will apply the basic data and technical information to problems of land-use planning in the Bay region. A few of the first and second types of reports pertaining to the South Bay area were published during the course of this Bayland salt-water flood control study, and were available to the study team.

CHAPTER V

LOCAL PLANNING AND POLICIES

Six cities, the County, military and aero-space agencies, and Leslie Salt Company constitute the principal entities having legal jurisdiction over or an ownership interest in a portion of the total Baylands study area. These interests, and present policies concerning the area, are described in this chapter.

A. BAYLANDS SUBCOMMITTEE, PLANNING POLICY COMMITTEE

The Planning Policy Committe (PPC) is comprised of representatives from each of the fifteen cities of Santa Clara County and from the County. Its purpose is to develop countywide planning policy to be implemented by the cities, the County, and other affected agencies having jurisdiction. It is staffed by the County Planning Department. The Planning Policy Committee undertakes studies and policy formulation through subcommittees. Pertinent to the work of this salt water flood control planning study is the work of the Baylands Subcommittee.

The Baylands Subcommittee of the Planning Policy Committe worked over a period of approximately eighteen months in carrying out staff and consultant research on the geology and structural engineering aspects of the Baylands, on transportation affecting the Baylands, on recreational criteria and potential, on flood control, on estuarine ecology, on solid waste disposal in the Baylands, on ownership and governmental power, on the climate of the Baylands, on wildlife, on water quality and circulation, and on existing land use and current proposals. This research was followed by subcommittee review and discussion, the formulation of policies, and finally the adoption of goals and policies. On February 24, 1972, the Baylands Subcommittee presented its recommendations in the form of *A Policy Plan for the Baylands of Santa Clara County* to the Planning Policy Committe. The planning Policy Committee transmitted the goals and policies to the cities, County and other concerned jurisdictions for a 90-day review period, and adopted the Policy Plan after this review.

The policy Plan states that its goals and policies "recognize the South Bay and its adjacent lands as unique and irreplaceable resources important to the total environment of Santa Clara County and that they are in concert with the basic objectives" of the BCDC San Francisco Bay Plan. Its primary goals pertain to the preservation and enhancement of all water areas--the Bay, marshlands, wetlands, salt ponds, sloughs, and creeks--and to the wise use of dry land areas in a manner compatible with and supportive to the water area policy.

Pertinent to flood control is the Policy Plan goal of providing "protection from flooding for those areas appropriate for urban development." The twelve flood control policies are as follows:

1. The proposed land use policy plan to be developed by the PPC should set the guidelines for future flood control improvements in the Baylands.

2. For long term economy of public costs, major flood control and drainage improvement planning by watersheds should precede any further urbanization of Baylands where designated in the PPC Plan.

3. The benefit-cost analysis of different flood control system alternatives should include the financial impact of possible changes in water, air and climate quality and increased public liability in the urbanization of marginal lands.

4. Reconstruction or strengthening of the dike system should reflect the adopted policies of the PPC Baylands Policy Plan.

5. Improvement of the inboard dikes for flood control purposes should be encouraged and any major improvements of the outermost dikes discouraged since improvement of the latter would tend to facilitate and increase the pressure for filling and urbanization of the salt ponds.

6. Any development with the exception of some small-scale recreational development should have protection from the 100-year flood.

7. Costs of flood control facilities should be applied proportionately to those areas which are benefited as well as those areas which contribute to flood runoff.

8. Acquisition or dedication of land for open space should be obtained before flood control improvements are made because it is more costly to the public after improvement.

9. Land use planning in the Baylands should use floodable open space land uses, where appropriate, to lessen the costs of flood control facilities and to preserve open land and water surfaces.

10. Multiple-use concepts which would contribute to the preservation of open space and the provision of more public recreational opportunities should be applied to the planning and design of flood control facilities.

11. That portion of the Baylands below an elevation of 10 feet above mean sea level should be placed in a special category of land use that recognizes the high flood

risk, where the relative safety of the dike system has not been established. Such a category would have the objective of warning property owners of the flood threat and of limiting future development in this area until the threat is removed. A fringe area should be similarly zoned since continued future subsidence will cause the area of potential flood threat to extend gradually. The potential future subsidence should be carefully evaluated to determine its probable magnitude and the increased areas of the Baylands that will be subject to salt water flooding.

12. Groundwater recharge should be encouraged as one way to reduce subsidence and consequent flooding.

Other policy statements in the Policy Plan which are particularly pertinent to this study include the ecological policies which advocate the preservation of Baylands marshes and wetlands as permanent wildlife areas and the restoration wherever possible of those marshes which have beeen destroyed; the restoration of tidal flow to the section of the New Chicago subdivision east of the new railroad spur; and the preservation of the Palo Alto flood basin "in its natural state." The recreational policies include a statement that recreation and other land uses should be weighed relative to . . . long term resource considerations, with the natural resource taking precedence.

The Policy Plan report contains an extensive summary of the findings of each of the separate studies which serve as the basis for the recommended policies.

The significance of the Baylands Subcommittee report on *A Policy Plan for the Baylands of Santa Clara County* to this study on salt water flooding is that it represents a current official countywide review and updating of policy pertaining to the area of this study and its present use, and the collective recommendations of its constituent members as to its future course of development. It is a comprehensive planning policy statement that is extremely pertinent to the evaluation of alternative flood control measures and plans. Adoption by the city councils and the Board of Supervisors whose jurisdictions are represented on the Planning Policy Committee will increase the importance of the policies as guides to future planning.

B. CITY OF PALO ALTO

Most of the Baylands in Palo Alto are owned by the City itself and consist of 3,900 acres between San Francisquito Creek and Charleston Slough which are susceptible to salt water flooding. (See Plates 2 and 4.)

The northwest areas occupied by the Airport and Yacht Harbor are leased to Santa Clara County, which built and maintains these facilities. The new Palo Alto-Mountain View-Los Altos water quality control plant is located just south of the Yacht Harbor.

To the east of this is the municipal refuse dump, which is the only area of the City's Baylands above the 10-foot elevation. An International Telephone and Telegraph Company (ITT) receiving network occupies a large tract of land between the dump and the Bayshore Freeway which is unincorporated but entirely surrounded by the City of Palo Alto. All of the above areas are surrounded by a perimeter levee, portions of which have been built and maintained by the Flood Control and Water District. The area is in a public facilities zoning classification, except the ITT property, which is classified as agricultural, the most restrictive use classification applicable to private property in Santa Clara County.

San Francisquito Creek, a flood control channel, is bordered by the Municipal Golf Course in the Palo Alto Baylands, and by the so-called Faber Tract levee across the channel in San Mateo County. Inboard of these properties, areas along the Creek banks are fully urbanized.

The Santa Clara County Flood Control and Water District maintains a large flood retention basin between Mayfield Slough and Charleston Slough. This basin, since its removal from tidal action, has become a brackish wildlife area and is principally dry grassland during most of the year. It is designated by the City of Palo Alto as the Palo Alto Marshland Preserve.

The open water area outboard of the Bay shoreline is zoned by the City as a flood area. Ownership is claimed by the Ideal Cement Company, although the title status may be subject to dispute by the State.

The City's 1963 general plan is presently undergoing revision, but the basic concepts pertaining to recreation, city facilities and some urban uses in the Baylands apparently continue. The ITT property may be sold and developed--possibly as urbanized recreation--though no specific plan is associated either with it or with the adjacent city-owned area now being filled with refuse.

The Shoreline Regional Park Plan, developed by the County Parks and Recreation Department as the Three Finger Lakes Plan, failed to gain funding approval in a 1969 bond election and has since lost some support. This plan would utilize the Palo Alto flood retention basin plus the two adjacent salt ponds north of Mountain View for combined flood control and recreational uses. However, some citizen groups have strongly opposed dredging of the Palo Alto flood basin, contending that this would diminish its wildlife value. From the County point of view, action on the park concept has been held in abeyance pending Planning Policy Committee action, but the County Preliminary Plan of Regional Parks developed in 1971 retains it for long-term implementation.

C. CITY OF MOUNTAIN VIEW

In Mountain View, the area adjacent to the Bayshore Freeway, between Charleston Slough and Stevens Creek, is in private urban uses. Agricultural uses with deteriorating semi-rural residences occupy the intermediate lands between the Bayshore Freeway and the salt ponds. The area Bayward of Charleston Road is susceptible to salt water flooding. (See Plates 2 and 4.) The northern City limit bounds a 550-acre regional park development now under way on City-owned property. The salt ponds north of this park development, part of the Leslie Salt Company holdings, are in unincorporated county land which has an agricultural zoning classification. The open waters beyond the salt ponds are claimed partly by the Ideal Cement Company and partly by the State.

The regional park area, a former marsh, is being filled by a sanitary land fill method of high quality. Refuse has been received since 1970 from the City of San Francisco. The first-phase area, between Stierlin Road and Permanente Creek, is nearly finished.

The City's sewage disposal facility occupied a site at the southern-most tip of Mountain View Slough. This plant was converted in the fall of 1972 to a pump station along the line to the new Palo Alto-Mountain View-Los Altos water quality control plant south of Palo Alto Yacht Harbor.

The completion date for the regional park land fill is currently under review. The original contract for San Francisco refuse anticipated a five-year period of operation. This may be changed to 10 years with a 1980 completion date. Filling of the north and east boundaries of the park, along the salt ponds and along Stevens Creek, are in the last phases of the fill project.

The remaining 850 acres between the park and the Bayshore Freeway have been under planning review by the Environmental Planning Commission of the City. Although the two salt ponds north of the regional park are not presently within the city limits, they are within the City's sphere of influence. The Mountain View General Plan provides that the Bay and the salt ponds remain indefinitely in open, undeveloped water uses, and cites a number of reasons for this policy. It states that:

> "The character of the South Bay was not essentially changed by the creation of the salt ponds. Tidal action has been arrested in the ponds, but the effect of the area upon the wildlife and the weather remains generally the same. In the half century of existence of the ponds, the ecology of the Bay has adjusted to accommodate the relatively minor change in the character of the area. . . . Should the salt industry no longer require this area, it should be devoted to other uses consistent with the maintenance of this water element, such as recreation, wild life preserves, or fisheries."

D. MOFFETT NAVAL AIR STATION and AMES RESEARCH CENTER

Two agencies of federal government own the unincorporated area between Mountain View and Sunnyvale, the Navy Department and the National Aeronautic and Space Agency (NASA).

The Navy operates the Moffett Naval Air Station which is dominated by a 9,200-foot runway and hangars. Personnel offices and quarters also occupy the southern part of the site. A golf course lies to the northeast, bordering the salt ponds. At the bayward end of the runway, which is susceptible to salt water flooding, is a diked marsh, and beyond this are salt ponds located partly within the city limits of Sunnyvale and partly in an unincorporated area.

The NASA Ames Research Center consists of over 40 wind tunnels and related research equipment and offices. Plant value is about $230 million. Most of the development is in the southern end of the site, though a new magnetism research facility occupies a northerly site location, near the diked marsh area outboard of the Moffett runway. The diked marsh area bordering the north end of both the NASA and the Moffett sites lies below mean sea level. It has no drainage system and consequently ponds rainwater. A large portion of the site adjacent to Stevens Creek is leased for agricultural use at present.

The Navy intends to continue current levels of operation at least to 1980, though no major changes in facilities or land use are foreseen. Flight clearance requirements for the runway impose constraints on future change of use or development in the salt ponds outboard of the runway.

NASA is in the process of acquiring adjacent parcels for an anticipated major expansion to the north and west, although there is still some uncertainty about these plans. A 1968 master plan is used to guide this development and includes a drainage system element which would locate a $350,000 drainage basin and pump station in the northernmost part of the site where the two magnetic research facilities are located. This development is tentatively scheduled in three to five years. Thought has also been given to construction of a drainage water treatment pond where cooling-tower waters could be treated before discharge into Stevens Creek. These waters often contain pollutants such as phosphates or chromates.

E. CITY OF SUNNYVALE

Land between the new Mountain View-Alviso Freeway Route 237 and the salt ponds is changing from agricultural use to primarily industrial use, in conformance with its zoning classification. On the west, the Lockheed Missiles and Space Company has intensively developed a sizeable portion of its site. Adjacent to this is Moffett Industrial Park where infrastructure for industrial tenants has been developed. South of the freeway there are some residential areas as well, including mobile home parks. Portions of the city on either side of Route 237 are susceptible to salt water flooding. (See Plates 2 and 4.)

The City has a refuse fill in operation at the inboard edge of the salt ponds near the sewage treatment plant. Two former salt ponds outboard of the Lockheed property are now owned by the City and used as oxidation ponds for sewage treatment.

The City limits include a large area of Leslie salt ponds outboard of Moffett Field and smaller holdings in the open water owned by the Ideal Cement Company and the State.

Moffett Channel, a drainage ditch running from the airfield to Guadalupe Slough, has recently been improved by Lockheed along the portion of the channel fronting its property. The improvements include raising the south levee elevation along Moffett Channel and the creation of a small storm water retention basin. A pump station was also installed with a pipeline from the retention basin parallel to the south levee and outfalling into Sunnyvale West Channel near its intersection with Moffett Channel.

Development in the salt ponds is under a moratorium and no intensive use of the area is contemplated at this time. The Shoreline Freeway, once a part of the State freeway plan, is included in the 1963 General Plan but is no longer regarded as part of current anticipations or policies although it has not yet been officially rescinded.

The 135-acre refuse fill area near the salt ponds is planned for park use and the City intends a joint development program with the County. Study funds for it were not passed in the 1969 County bond election, but it is included in the County park plan and program.

The City anticipates operation of its sewage facilities until the year 2000 or longer, including use of the oxidation ponds, after which time consideration may be given to diverting its sewage to the San Jose-Santa Clara treatment plant.

A legal agreement exists between Lockheed and the Flood Control and Water District concerning Moffett Channel, which obligates the Flood Control and Water District to pay for original construction costs and assume responsibility for maintenance of the channel improvements made by Lockheed if the District determines that such an undertaking is within its jurisdiction as part of an overall Baylands flood control program.

F. CITY OF SANTA CLARA

The Baylands portion of the City boundaries follows Route 237 between Calabazas Creek and the Guadalupe River. Agricultural uses are continuing here, although industrial uses have begun to locate in this area. A municipal refuse dump is located off Lafayette Street, the Santa Clara-Alviso Road. Present zoning is mixed between public facilities and agricultural classifications. Land fill has been used in a few developed areas near Route 237 which are subject to salt water flooding or fresh water inundation. (See Plates 2 and 4.) The primary urban development within the City is located further south along the Guadalupe River, near Agnews State Hospital.

The general plan adopted by the City in 1970 allocates the Baylands area primarily to industrial uses, with some residential uses south of Route 237. A park area bordering the Guadalupe River and Route 237--the Santa Clara County Valley Floor Park--is indicated in the General Plan. Because of current development proposals on a portion of the site, present attitudes of City officials are tending to favor industrial use of this land. The park remains in the County park program, but on a long-term basis. A 1968 study report for the park envisioned a dual purpose recreational lake and local drainage basin.

G. CITY OF SAN JOSE

San Jose occupies the largest portion of the Baylands in Santa Clara County since its consolidation of Alviso. The salt ponds, marshes and sloughs from Guadalupe Slough on the west to Coyote Creek on the east fall within the current City boundary.

Areas adjacent to Route 237 are still primarily in agricultural use. A half-mile north of this main circulation artery, situated on the east bank of Alviso Slough, is the small community named after Ignacio Alviso. This formerly independent town contained 251 dwelling units in 1970 of which 48 percent were considered substandard. It has three quality restaurants and bars, a couple of small hamburger-taco cafes, a couple of small general grocery stores, one filling station-garage, one elementary school, three boatworks, the new small-boat harbor maintained by the County, a small boat slip at the private South Bay Yacht Club, several junk-yards, a miscellany of brick, wooden and metal warehouses and sheds, and dumps. The streets are paved but broken; sidewalks are few. Two-thirds of the residents are renters.

Alviso is the only self-contained community in the study area. Flooding is the most serious problem confronting the community of Alviso. Portions of the community have subsided to an elevation of -2.0 feet. It has experienced widespread fresh water flooding from Coyote Creek and the Guadalupe River, most recently in 1969, 1963, 1958 and 1955. It is also susceptible to salt water flooding, since most of the levees now protecting the area were built to enclose the salt ponds and consequently were not constructed to standards necessary to protect life and property in an urban environment. (See Plates 2 and 4.).

The newest and most handsome building complex is the Family Health Center which is the social and political center of this Mexican-American community as well. In 1970 the San Jose Planning Department established an Alviso Planning Committee composed of four major groups within the community and a representative of the local school district to develop a land use plan. The committee voted to dissolve when it had completed 90 percent of a generally acceptable plan. As a legacy, it left an Interim Policy Guide which was published in December 1971. The policies enunciated are designed to strengthen the economy of the existing community and improve its physical facilities and appearances. Included are the establishment of a Mexican-American cultural center and the creation of a special Marine District for water related industrial and commercial activities. Reference is made to the "Alviso Bay" concept of recreational and resort development of the salt ponds in the area between Alviso and Guadalupe Sloughs, noting that "if desirable and feasible, such a project is in the distant future."

The most Bayward part of the salt ponds between Guadalupe and Alviso Sloughs is privately owned and is being deeded over a period of time to Nature Conservancy. The parcel has a fresh-water well and a duck-hunting club house.

Northeast of Alviso is the New Chicago Marsh, a diked-off area adjacent to the salt ponds, which receives tidal circulation at only a few places. A new railroad spur line was recently built through it to provide chemical delivery service for the San Jose - Santa Clara sewage treatment facility. The main Southern Pacific Railroad line from the East Bay crosses the salt ponds, skirts the edge of the marsh, and passes through Alviso. The New Chicago Marsh has been platted for many years and is in mixed public and small private ownership, though less than half of the original subdivision is developed. The entire area is zoned residential. The San Jose - Santa Clara sewage plant site and most adjacent lands are owned by the City.

Newby Island lies between the main and the southeast branches of Coyote Creek. It is owned by a private company and is currently used as the San Jose refuse dump. The zoning classification of Newby Island permits multiple-family residential use.

H. CITY OF MILPITAS

At the eastern edge of the Baylands study area is the City of Milpitas. It is a growing industrial center whose automobile assembly plant and other activities are served by two railroads.

From the Nimitz Freeway west to Coyote Creek, the area susceptible to flooding, the primary land use is agricultural. To the north, near Dixon Road, is the City's sewage treatment plant wich occupies a six-acre site, protected by high levees. All zoning is agricultural. East of the Nimitz Freeway there are low density residential developments in the vicinity of the Calaveras Boulevard interchange.

The agricultural land between the Nimitz Freeway and Coyote Creek, north of the Calaveras Boulevard interchange, was changed by amendment of the City's General Plan from urban reserve to industrial uses. The area fronting Coyote Creek below the interchange remains designated as an urban reserve. The City plans continued use of its sewage facility. Expansion of treatment capacity has not yet been planned.

I. LESLIE SALT COMPANY

The Leslie Salt Company, founded in 1919, is the largest single property owner in the Baylands study area, having a total of 8,700 acres of which 7,700 acres are in salt ponds. These comprise a small but key portion of its San Francisco Bay holdings in four counties, totalling close to 50,000 acres.

The system of salt production ponds within the study area runs between Charleston Slough and Newby Island. Salt water from the Bay is taken in at Charleston Slough at a point between the Stevens Creek outfall and Guadalupe Slough, and at Alviso Slough, is allowed to evaporate in the ponds, and is pumped across sloughs or under dikes in an easterly direction to successively more saline ponds. The Santa Clara Baylands pond system is continued in the Alameda County system and the final salt product is harvested at Newark. The evaporation process takes about five years and yields approximately 40 tons of nearly pure salt per acre per year, averaged over the total pond system. This salt extraction process plays a vital role in the economy of the Bay Region, and supplies chemicals used by local industries without the transportation costs applicable to salt products imported from other salt-producing regions.

The Baylands salt ponds, especially the less concentrated ones, are used by migratory wildlife species for resting places and for some food supply, since brine shrimp and other organisms grow in the various stages of pond salinity. Very little public access occurs along the levees and shoreline in the salt pond areas because the Company maintains a controlled access policy.

The Company has applied to several municipalities and to the County to have salt ponds included under the assessment provisions of the California Land Conservation Act of 1965, the Williamson Act. This Act permits taxation of the ponds at a lower agricultural rate not subject to appraisal criteria applied to lands under the pressures of urban development. The applicant in turn makes commitments in 10-year increments not to develop the lands for urban uses. The salt ponds in the unincorporated areas of the

County have been approved for treatment under the Williamson Act.

The company objectives generally have been to maximize flexibility in planning and to seek just compensation for lands given over to public uses. There is a continuing interest in obtaining approval under the Williamson Act since this will lower land holding costs and improve the incentive to continue salt production. In the short run the Company seeks to continue salt production on a basis compatible with other public uses which may be proposed, such as the National Wildlife Refuge. Leslie Properties, Inc., the land development branch of the Company, has produced a preliminary sketch plan of possible long-term development in the South Bay pond system, including a mix of urban and public open spaces. This plan was first presented publicly at a meeting of the Baylands Subcommittee of the Planning Policy Committee on October 15, 1971.

In the Santa Clara County area the plan includes "urbanized lake" developments of the salt ponds north of Mountain View consisting of clusters of housing on recreational lakes; development of the ponds adjoining Moffett Field and Sunnyvale for industrial uses, denser residential development between Guadalupe and Alviso Sloughs with Guadalupe Slough greatly widened to provide both open recreational waters and fill material; an "urbanized lake" east of Alviso Slough; and portions of the proposed National Wildlife Refuge, including the northern portion of the New Chicago Marsh. The sketch plan has no target date associated with it nor any phasing of development, and it is has not been adopted as official company policy.

On November 16, 1971, Leslie Salt Company announced its intention to sell its land holdings and its salt production facilities. The use and development policies of the future holder of these properties is presently one of speculation. It is anticipated, however, that salt production will be continued as the principal use so long as it is economically feasible.

J. SANTA CLARA COUNTY

Only a small portion of the Baylands is not incorporated into one of the six municipalities in the study area. Unincorporated areas consist of the salt ponds and open water north of Mountain View, Moffett Field, and miscellaneous parcels in the upland areas inside the limits of Mountain View, Santa Clara, San Jose, and Milpitas.

However, in addition to the countywide Planning Policy Committee and its Baylands Subcommittee, discussed in Section A of this chapter, there are other County agencies with concern for and responsibilities in the study area. The most important, in relation to the purposes of this study, are the County Department of Public Works and the County Parks and Recreation Department.

1. Department of Public Works

The Department of Public Works is responsible for the design, engineering and maintenance of the public boat harbors at Palo Alto and Alviso; for the supervision of dredging of the Alviso and Guadalupe Sloughs and Calabazas Creek for the Flood Control District; and for response to specific inquiries from the Board of Supervisors. It was a query from the Board of Supervisors as to whether the County should buy a dredge that led to the formulation of the Bayfront Plan in 1969. Developed as a measure for determining cost parameters as a basis for an answer to the specific question, the Bayfront Plan proposed that the outermost levees at the edge of the Bay be raised and widened to an average width of one thousand feet. Vehicular access was proposed to points along the edge by similarly widening certain levees along the flood channels leading from the valley floor to the Bay. The raising and widening of the land barrier was proposed to be accomplished by the dredging of existing channels and the Bay floor beyond the low water tidal flats in the amount of approximately 30 million cubic yards, at an estimated cost of $15 million. The Bayfront Plan was opposed by many groups and was not approved by the Board of Supervisors.

2. Parks and Recreation

In June 1971 a revised Preliminary Plan of Regional Parks for Santa Clara County was published by the County Planning Department. Developed cooperatively with the Parks and Recreation Department and two subcommittees of the Planning Policy Committee, the plan provided for the acquisition and development of five Baylands sites. These are the Charleston Slough area, Salt Pond No. 1 east of Charleston Slough, the easternmost portion of the Sunnyvale Baylands Park area in Santa Clara and near Alviso, the eastern portion of the New Chicago Marsh, and the northerly portions of the Coyote Creek Park Chain. A charter amendment permitting a 10-cent property tax to assist in carrying out the program was approved by the voters in June 1972.

3. Zoning

An examination of the provisions of the general plans of the various jurisdictions in the Baylands and of the composite land-use zoning pattern shows a wide discrepancy between the two as well as between the use zones and the practical adaptability of some of the land for uses permitted in the prevailing zoning districts. Few of the zoning ordinances in the County and its cities make provision for use districts applicable to water or inundated areas, or for flood plain zoning. The planning directors of the County have recommended that such provisions be adopted by each jurisdiction in the Baylands, and have developed a model prototype for inclusion in current zoning ordinances.

The purposes of such a zone would be to identify areas of San Francisco Bay, inundated areas, and areas subject to flooding along the Bay, to provide for uses appropriate to such lands in the interests of the ecology of the area and in the interests of protecting persons and property from hazards of development in such areas, and to protect the community from the costs which might be incurred if unsuitable development were to occur. Permitted uses would be water- and wetland-related, ranging from recreational uses to salt extraction. Such a flood-plain zoning provision would more nearly reflect present realities and future policies and practicalities of use.

K. NATIONAL WILDLIFE REFUGE

Fostered by the ad hoc South San Francisco Baylands Planning, Conservation, and National Wildlife Refuge Committee, studied by the Bureau of Outdoor Recreation and the Bureau of Sport Fisheries and Wildlife, and supported by the Department of Interior in congressional hearings on bills to establish it, the San Francisco Bay National Wildlife Refuse received congressional approval in the spring of 1972 and the legislation was signed by the President on June 30, 1972. Primary funds for acquisition and development will come from the Migratory Bird Conservation ("duck stamp") Fund, and the Land and Water Conservation Funds for endangered species.

The refuge is located in three counties: Alameda, San Mateo, and Santa Clara; and in the cities of Fremont, Redwood City, Menlo Park, and San Jose. The portion in Santa Clara County extends from the Alviso Slough eastward, including all of the salt ponds and the portion of the New Chicago Marsh east of the new railroad spur, and is approximately 3,000 acres in extent. In support of the refuge, the San Jose City Council reclassified the zoning of the area fron industrial to agricultural, its most restrictive use-district classification. A regional airport site that was once proposed in the area was dropped from consideration by the Regional Airport Systems Study Commission in its evaluation of regional airport needs and sites published in June, 1972.

Leaseback privileges to Leslie Salt Company, in order to permit continued salt production, are envisioned. Past curtailment of salt production elsewhere on San Francisco Bay, and the draining and subsequent filling of other salt ponds for commercial and residential developments has contributed, in part, to the widespread support of the wildlife refuge concept. There are three primary objectives of the refuge. The first is to preserve and maintain fish and wildlife habitat necessary to support sizable populations of migratory waterfowl and other migratory birds, indigenous flora and fauna, and endangered wildlife species. The second is to provide and protect unique fish and wildlife areas for human use and enjoyment. The third is to maintain open space, open water, and marsh and tidal mudflats uniquely situated in the heart of a metropolitan area, all of which are considered to be beneficial to man's health and welfare.

The Alviso unit of the refuge is intended to include an interpretive and educational center, a wildlife trail, board walks, a wildlife observatory and fishing platforms along channels. Overwater hunters' blinds would be provided for limited public hunting.

Establishment of this wildlife refuge constitutes a major land use decision and consequent determinant of needed flood control measures.

CHAPTER VI

POPULATION, EMPLOYMENT, AND LAND USE

The existing character of the Baylands study area, its present uses, and its evolving and sometimes conflicting development policies have been reviewed in Chapters IV and V in terms of the sub-areas and varied interests that comprise the political and economic framework of the study area.

Consideration of the potential character and development of the Baylands under alternative plans for protective levees also should be done within the context of the broader area with which the Flood Control and Water District is concerned, namely, the entire County of Santa Clara. Proposed protective levees in the Baylands must be considered not only in terms of priorities within the Baylands, but also in terms of area-wide priorities. To this end, present and future land use in the Baylands are considered in this chapter in the context of county growth and the need for land for various purposes to accommodate that growth.

A. POPULATION AND EMPLOYMENT

For the purpose of this study, it was deemed necessary that population projections for Santa Clara County should cover a period of 50 years since capital projects of the type under consideration should have an economic life of at least 50 years. It is assumed that flood control levees in the Baylands will be built to last for an indefinite future and that, once in place, the levees will be maintained more or less in perpetuity. A 50-year period of utility is thus a minimum period selected for comparative analysis. For the purpose of this study, the year 2020 was selected to be approximately the 50th project year.

1. Population Growth in Santa Clara County, 1900 to 1970

Historical population growth in Santa Clara County is compared in Table 2 with population growth in the United States, in California and in the nine-county San Francisco Bay Area. Population growth in Santa Clara County lagged behind state growth between 1900 and 1940, as is shown by the declining percent of state population in the county in each decade. However, after 1940 growth was more rapid in the county than in the state. From a low of 2.53 per cent of the California total in 1940 Santa Clara County grew to contain 5.43 per cent of the total population in California in 1970.

Another indication of relative growth is seen in comparative ratios which have been computed for the United States, for California, for the San Francisco Bay Area

TABLE 2

POPULATION GROWTH IN THE UNITED STATES, IN CALIFORNIA, IN THE SAN FRANCISCO BAY AREA, AND IN SANTA CLARA COUNTY

1900 to 1970

(in 1000's)

Year	United States	California	San Francisco Bay Area	Santa Clara County	
				Number	% California
1900	75,994.6	1,485.1	658.0	60.2	4.05
1910	91,972.3	2,377.5	925.7	83.5	3.51
1920	104,710.6	3,426.9	1,183.0	100.7	2.94
1930	122,775.0	5,677.3	1,578.1	145.1	2.56
1940	131,669.3	6,907.4	1,734.4	175.0	2.53
1950	151,325.8	10,586.2	2,681.3	290.5	2.74
1960	179,323.2	15,863.0	3,676.2	658.7	4.15
1970	200,263.7	19,703.0	4,591.2	1,070.0	5.43
Ratio:					
1970 to 1900	2.64	13.27	6.98	17.77	

Source: U.S. Census Data. The San Francisco Bay Area in the tabulation includes the counties of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano, and Sonoma.

and for Santa Clara County between 1900 and 1970. Whereas there were a little more than 2.5 times as many persons in the United States in 1970 as in 1900, there were 13 times as many in California. Whereas there were 7 times as many persons in the San Francisco Bay Area in 1970 as in 1900, there were almost 18 times as many in Santa Clara County. The greater relative population growth in the County as compared with the other areas is all the more remarkable when it is recalled that the greater part of this 70-year growth has occurred in the past 30 years.

It was World War II that gave a sudden boost to the Santa Clara County economy and led to the establishment of many new industries in the area between Palo Alto and San Jose. This industrial base was expanded subsequently and many new firms have been formed by individuals who first became acquainted with the area during their employment with one of the larger firms.

Although Santa Clara County is a pleasant place to live, in spite of some unfavorable aspects of its recent growth, growth did not occur to any extent until job opportunities began to develop in the area. After World War II population and employment in the San Francisco Bay Area, as in other metropolitan centers, tended to move out from the center as factories grew old and had to be replaced, and as land values rose and made continuation of production in the more congested areas unfavorable. The relatively low cost and availability of open areas at the margins of existing centers made them attractive to industry. In the San Francisco Bay Area San Clara County shared in that outward movement with Alameda and Contra Costa counties to the east and north. Now that a substantial and varied industrial base has become established in Santa Clara County, it is believed by most students of the area that further growth will be fostered by the already existing development.

2. Employment in Santa Clara County from 1940 to 1969

The outstanding growth in County employment has been in manufacturing, as shown in Table 3. Whereas population grew sixfold between 1940 and 1970, manufacturing employment grew fifteenfold. Most of the growth in manufacturing employment was in the durable goods fields. In 1940 there were about two persons employed in non-durable manufacturing to each one in the durables fields. In 1970 there were four persons employed in the durables fields to each one in the non-durables.

Not only did employment in manufacturing exceed population growth, but employment by various levels of government grew much more rapidly than population. Service employment and employment in finance, insurance, and real estate also gained relatively. However, food processing, which was long a major factor in the economy of Santa Clara County, did not increase in proportion to population, partly because agricultural lands were converted to other uses and the local supply of fruits and vegetables was reduced in relation to other growth.

Of the 128,600 persons employed in manufacturing, 73,200 persons were employed in the aerospace industry in 1969. This unusual concentration of employment explains in large part the substantial growth in the County.

3. Projected Population Growth to 2020

Projections of population growth in the nation and in California are generally much lower at this time than they were before the 1970 census was taken. Although it was recognized that growth in the nation and in California had slowed during the 1960's, the full significance of that slowdown was not appreciated fully until data compiled in the 1970 census were released.

TABLE 3

AVERAGE ANNUAL EMPLOYMENT IN SANTA CLARA COUNTY IN SELECTED YEARS, 1940 TO 1969

(1,000's)

Employment Field	**1940**	**1950**	**1960**	**1969**	**Ratio 1969 to 1940**
Agriculture	9.4	16.2	11.1	7.2	.77
Contract Construction	4.7	9.4	17.8	20.3	4.32
Manufacturing	8.6	22.1	70.3	128.6	14.95
Durables	3.0	9.0	51.6	101.4	33.80
Non-Durables	5.6	13.1	18.7	27.2	4.86
Food	4.1	10.9	12.7	15.3	3.73
Transportation, Communications, and Utilities	3.6	6.1	9.6	16.4	4.56
Trade	12.6	22.6	40.7	75.8	6.02
Finance, Insurance, and Real Estate	2.1	3.2	7.9	15.2	7.24
Service	13.6	18.3	43.2	91.8	6.75
Government	5.1	11.7	26.8	56.4	11.06
Others	.5	.3	.6	1.0	2.00
Totals	**59.9**	**109.9**	**228.0**	**412.7**	**6.89**

Source: Data from table in Santa Clara County Profile, prepared and distributed by Santa Clara County Chamber of Commerce.
Original source: California Department of Human Resources.

At the national level the reduced rate of population growth is attributed primarily to a reduced rate of natural increase--births over deaths--inasmuch as in-migration has not contributed to a very large part of the nation's population growth for some years. In California the slowdown is partially due to a reduction in the rate of natural increase, but is largely attributable to a change in the extent of in-migration from other states. Apparently the State is no longer as attractive to people from other parts of the United States and so they are not coming in such large numbers as characterized the rapid growth period, and of those who do come, more return home after a brief period than had been the case in recent years.

Employment opportunities in California contributed to a major part of the net movement to the State in the war and post-war period. Most of the population growth in Santa Clara County was due to the drawing power of the new industry in the area. Growth was uniquely related to in-migration rather than to natural increase. With a general slowdown in population growth nationally and in the State, it can be expected therefore that Santa Clara County will not grow as rapidly as it did in the recent past.

Within the State and within the San Francisco Bay Area, however, it appears that Santa Clara County will grow somewhat more rapidly than the regional average. The momentum of its recent growth has not spent itself entirely, and the outlook for the future is for higher than average growth. Without exception, forecasters of economic growth show Santa Clara County exceeding other counties of somewhat equal size and development. Within the San Francisco Bay Area it is assumed that Santa Clara County will share with southern Alameda County a large part of the further dispersal of industry from the older centers to the periphery of the metropolitan area.

The California Department of Finance recently released new population projections for the State and for each of the counties, which carry forward to the year 2000. Projections being made at this time are more conservative than those made in the recent past, as the Department figures, shown in Table 4 indicate.

TABLE 4

PROJECTED POPULATION GROWTH IN THE UNITED STATES, IN CALIFORNIA, IN THE SAN FRANCISCO BAY AREA, AND IN SANTA CLARA COUNTY

1970 TO 2020

(1000's)

Year	United States	California	San Francisco Bay Area	Santa Clara County	
				Number	% California
1970	200,264	19,703	4,591	1,070	5.43
1980	227,000	23,549	5,493	1,387	5.89
1990	250,000	28,188	6,556	1,760	6.24
2000	270,000	32,567	7,545	2,103	6.46
2010	287,000	36,500	8,500	2,400	6.58
2020	300,000	40,000	9,400	2,720	6.80
Ratio:					
2020 to 1970	1.50	2.03	2.05	2.54	

Sources: Projections for California, the San Francisco Bay Area, and for Santa Clara County, 1980 to 2000, taken from the September 15, 1971, release of the California Department of Finance. Other figures estimated by the economist.

The population projections prepared by the Department of Finance are considered adequate for the purposes of this study. It was recognized at the start of this study that the Santa Clara County Planning Department would be making projections in the near future which would probably differ somewhat from the estimates made on a statewide basis. However, in the absence of revised figures at the local level and in the belief the state estimates are reasonable, the Finance Department projections have been used for the State, for the San Francisco Bay Area and for Santa Clara County to the year 2000. Projections to the year 2020 are smooth curve extensions of the growth patterns contained in the 1970-to-2000 projections. As explained by the Department in its release of population figures, projections must be made on the basis of many assumptions. If any of the assumptions prove to be incorrect, actual growth will differ from that projected. Whether the projections prove to be well founded and actual population in ten to fifty years is equal to that projected can be known only after the passage of the projection period. However, it is necessary to plan for capital improvements and to do so on the basis of reasonable estimates of future growth.

In broad terms, the projections show California growing more rapidly than the nation, and Santa Clara County growing more rapidly than the State. Although population growth is not projected to increase as fast as was once thought possible, there is still a large growth anticipated for Santa Clara County. About 300,000 more people will be living in the county in 1980 than were there in 1970. About 400,000 will be added in the following decade. By the year 2000, according to the State estimates, there will be over 2,100,000 persons in the County. In thirty years the population is expected to be almost double the 1970 level of 1,070,000. Extension of the projections made by the Department to 2020 results in another 600,000 persons being added to bring the 50-year level to 2,720,000 persons.

4. Projected Employment to 2020

Based upon the employment structure in recent years, upon trends in the relative importance of the several major types of employment in Santa Clara County and in the State of California, and in terms of the projected population growth, projections of future employment in the county have been prepared and are shown in Table 5. These projections show a continuation of the decline in importance of agriculture, a slight increase in manufacturing, mostly in nondurables, and increasing construction, trade, and services.

Continued growth in population in Santa Clara County indicates a continued growth in employment. The rapid growth in the past was associated with an unusual upsurge in manufacturing activities in the County. Estimates of future employment show employment leading population, rising from 400 employed persons per 1,000 population, to 431 per 1,000. It is believed that employment opportunities in the County will be the main force for growth in the future. More of the employment will be in locally

TABLE 5
AVERAGE ANNUAL EMPLOYMENT IN SANTA CLARA COUNTY PROJECTED BY MAJOR CLASSES BY DECADES TO 2020
(1000's)

Employment Field	1970	1980	1990	2000	2010	2020
Agriculture	6.7	6.8	6.9	7.0	7.0	7.0
Contract Construction	20.2	27.6	35.0	42.4	49.8	57.1
Manufacturing	128.0	170.0	212.0	254.0	297.0	340.0
Durables	101.0	130.0	160.0	190.0	220.0	250.2
Non-Durables	27.0	34.1	41.2	48.3	55.4	62.6
Food	14.8	18.4	22.0	25.6	29.2	32.6
Transportation, Communications, and Utilities	17.6	23.3	29.0	34.7	40.4	46.2
Trade	80.9	117.0	157.9	191.4	219.9	269.6
Finance, Insurance, and Real Estate	16.0	22.0	28.0	34.0	40.1	46.2
Service	97.2	131.7	176.3	210.7	239.5	
Government	60.2	69.7	89.2	108.7	128.2	157.8
Others	1.4	1.6	1.8	2.1	2.4	2.7
Totals	**428.3**	**579.8**	**746.3**	**902.2**	**1,034.4**	**1,175.0**

Source: Prepared by the economist.

oriented activities, however, such as trade and service, and in the production of manufactured products for the local and regional market. Less dependence will be placed on national and international markets.

B. LAND USE ASPECTS OF POPULATION AND POPULATION GROWTH

Land use data indicate the number of persons in an area and the activities in which they engage. In a rural area a large part of the land will be devoted to agriculture and a relatively small part to residential, commercial and industrial uses, In a large, metropolitan community, relatively little land is left open in any use, and the proportion of the total land area in residential, commercial, and industrial use is very large. When a rural area becomes urbanized, the transition of land use is one in which agricultural and relatively undeveloped lands decrease in acreage and residential, commercial and industrial lands increase.

At any point in time a community or county has an inventory of land which reflects earlier patterns of use and the changes which have occurred in the past. Of the total stock of land, a certain percentage will not yet be developed, but will be designated through zoning as suited to a more intensive future use. The land inventory at any time thus includes lands which are available for uses other than those to which they are currently being placed. It is appropriate that there be a reasonable amount of land so designated in that it makes possible a choice to those who may wish to develop a residential area or who may wish to build an industrial plant. Until such time as an area becomes saturated with growth and little or no land remains available, the acreage in the transitional category--used less intensively than authorized--may be quite large.

In 1967 when a land use inventory of Santa Clara County was made, there were some 15,700 acres located within and adjacent to cities which were classed as "urban, vacant", indicating that they were unused but suited to one or another of the urban uses. This acreage comprised almost 25 percent of all acreage in the County devoted to residential, commercial, industrial, public and other uses; for every four acres already developed with an urban type of use, there was one additional acre designated for future urban development.

The comprehensive land use inventory of Santa Clara County made in 1967 by the County Planning Department is the basis for the analysis which follows. Santa Clara County has a total of some 847,000 acres. Of this amount, 752,290 acres are subject to taxation. In 1967 when the land use inventory was prepared, there were about 960,000 persons living in the County. In Table 6 the assessed land use in 1967 is shown by major categories, and acres per 1,000 population are computed.

TABLE 6

LAND USE BY MAJOR CATEGORIES IN 1967
SANTA CLARA COUNTY

Land Use	Acres	%	Acres Per 1,000
Residential	48,175	6.40	50.18
Industrial	6,272	.83	6.53
Transportation, Utilities, etc.	1,422	.19	1.48
Commercial	4,329	.58	4.51
Public	7,087	.94	7.38
Urban Vacant	15,700	2.09	16.35
Agricultural	542,837	72.16	565.46
Other	126,469	16.81	131.74
Totals	**752,290**	**100.00**	**783.64**

Source: Basic data from land use inventory, 1967, Santa Clara County Planning Department. Percentages and acres per 1,000 computed.

Over 85 percent of the assessed land in the county in 1967 was in either agricultural use or in some other use considered not to be developed. Including vacant urban lands, the land not used for residential, industrial, commercial or other such uses represented about 90 per cent of the total. Conversely, only 10 per cent of the land in Santa Clara County was in urbanized uses.

1. Land Use Projections

Several methods of projecting land use needs were considered. The results of the alternative methods were not much different from a simple projection which used the existing ratio of acres per 1,000 population in conjunction with estimates of future population. Although such a simple projection infers that the ratio of land to population needed for all types of uses will remain unchanged, something not likely to occur, it has been used for the basic projection with variations thought to be likely being treated as percentage deviations from the figures derived from the simple computations.

Except for industrial acreage, land use is quite flexible. Experience has shown that residential developments may occur almost anywhere and that other related developments will be provided nearby to complement the residential activity. Industrial sites, however, in many cases require ready access to highways and to railroads, and must be relatively flat. Thus, not every acre is equally suited for industrial use. In addition, industrial development tends to cluster, newer plants being located close to older plants in order to gain advantages of closeness, either in terms of supply or of market. The location of industrial lands in the County, therefore, would appear to be more limited as to specific area than other uses.

The need for additional lands to supply the land use categories shown in Table 7 varies from 20,000 to 25,000 acres per decade or 2,000 to 2,500 per year. The need per decade for added industrial acreage is on the order of 2,100 to 2,400 acres or, on an annual basis, 210 to 240 acres per year. Over a 50-year period, there would be a need for about 11,000 additional acres of industrial lands.

In the aggregate, the 2,720,000 persons projected to be living in Santa Clara County in 2020 would need some 190,700 acres for all purposes except agriculture and open space. This represents slightly more than 25 per cent of the acreage in the County. Conversely, 75 per cent of the County land would remain open.

2. Location of Industrial Land

It was indicated above that industry is drawn to industry. While this is not a rule without exception, it does suggest that the location of industrial lands within the County in 1967 may be indicative of where industry may wish to locate in the future.

TABLE 7

LAND USE IN SANTA CLARA COUNTY PROJECTED TO 2020 BY MAJOR CATEGORIES OF ASSESSED LANDS

(Acres Per 1,000)

Item	1967	1970	1980	1990	2000	2010	2020
Population (In 1,000's)	960	1,070	1,387	1,760	2,103	2,400	2,720
Residential	50.18	53.7	69.6	88.3	105.5	120.4	136.5
Industrial	6.53	7.0	9.1	11.5	13.7	15.7	17.8
Transportation, etc.	1.48	1.6	2.1	2.6	3.1	3.6	4.0
Commercial	4.51	4.8	6.3	7.9	9.5	10.8	12.3
Public	7.38	7.9	10.2	13.0	15.5	17.7	20.1
Sub-Totals		**75.0**	**97.3**	**123.3**	**147.3**	**168.2**	**190.7**
All Other		677.3	655.0	629.0	605.0	584.1	561.6
County Total		**752.3**	**752.3**	**752.3**	**752.3**	**752.3**	**752.3**
% of Total Developed		10.0	12.9	16.4	19.6	22.4	25.3

Source: Projections of land use prepared by economist.

As shown in Table 8, in 1967 almost 80 per cent of the lands in the County which were used by industry were in seven cities located around the southern tip of San Francisco Bay. San Jose alone accounted for almost 30 percent of the industrial land in the County. Allowing for problems of land cost in these communities and for the availability of suitable land, it would appear that future development might occur in or near these cities. On the other hand, it does not appear that the communities of Campbell, Los Gatos, Cupertino, Saratoga, or Los Altos would increase their industrial development significantly, on the basis of the reasoning that new industry will be attracted to old industry. Of course, there are other reasons why these communities may not provide for very much industrial location in the future, including the lack of land area and a desire on the part of some of the communities not to have industrial development within their boundaries.

Although Santa Clara County industrial development has concentrated in the area at the southern end of San Francisco Bay in the past, there is reason to believe that a substantial part of future development may occur in the southern part of the Santa Clara Valley in and around the cities of Morgan Hill and Gilroy. Lack of substantial growth in the past has not been for lack of land area suitable for industrial use or for lack of rail or highway access. Although highway access has become increasingly difficult

TABLE 8

LOCATION OF INDUSTRIAL LAND USE IN SANTA CLARA COUNTY IN 1967

City or Area	Acres	%
San Jose	1,759	28.10
Sunnyvale	1,116	17.83
Santa Clara	682	10.89
Palo Alto	530	8.47
Mountain View	476	7.60
Milpitas	319	5.10
Alviso	26	.42
Sub-Total	**4,908**	**78.41**
Campbell	131	2.09
Los Gatos	37	.59
Cupertino	29	.46
Saratoga	15	.24
Los Altos	8	.13
Sub-Total	**220**	**3.51**
Gilroy	104	1.66
Morgan Hill	54	.86
Sub-Total	**158**	**2.52**
Sub-Total, Urban Areas	**5,286**	**84.44**
Unincorporated Areas	974	15.56
County Total	**6,260**	**100.00**

Source: Land use inventory, 1967, Santa Clara County Planning Department.

in recent years, it is anticipated that completion of the upgrading of Highway 101 to freeway standards will improve the flow of traffic in the future. Industrial plants requiring large land areas will probably be drawn to southern Santa Clara County in the future by the large land area available, the lower cost of land, and the availability of certain key raw materials. Once development has reached a reasonable level, it will induce other development as has been the case in the past elsewhere in and about the San Francisco Bay Area.

3. Location of Available Land

There was a total of almost 685,000 acres of open land in Santa Clara County in 1967. Some 15,700 acres of this was classed as urban vacant, but the greater part by far was classed as agricultural or other. On Table 9 the acres available for future development are arranged by types and location to correspond to Table 8 so that it can be seen to what extent open land is available in the areas where existing industrial lands are located.

TABLE 9

LOCATION OF AVAILABLE LANDS IN SANTA CLARA COUNTY IN 1967 BY TYPE

City or Area	Vacant Urban	Agricultural and Other	Total	
			Number	%
San Jose	4,103	32,281	36,384	5.31
Milpitas	1,745	1,234	2,979	.43
Sunnyvale	1,457	2,285	3,742	.55
Santa Clara	772	916	1,688	.25
Mountain View	572	858	1,430	.21
Palo Alto	534	6,036	6,570	.96
Alviso	78	6,717	6,795	.99
Sub-Total	**9,261**	**50,327**	**59,588**	**8.70**
Los Altos Hills	721	1,711	2,432	.36
Saratoga	649	2,493	3,142	.46
Los Gatos	608	1,228	1,836	.27
Cupertino	325	2,198	2,523	.37
Campbell	216	326	542	.08
Monte Sereno	156	132	288	.04
Los Altos	147	112	259	.04
Sub-Total	**2,822**	**8,200**	**11,022**	**1.62**
Morgan Hill	387	2,317	2,704	.39
Gilroy	182	1,038	1,220	.18
Sub-Total	**569**	**3,355**	**3,924**	**.57**
Unincorporated Area	3,050	607,318	610,368	89.12
Total	**15,702**	**669,200**	**684,902**	**100.00**

Source: 1967 Land Use Inventory, Santa Clara County Planning Department.

The seven cities in which almost 80 percent of the existing industrial acreage is located account for only 8.70 percent of the vacant land in the County. However, even that 8.70 percent is ten times the acreage devoted in 1967 to industrial purposes. As compared with the estimated future need for about 11,000 acres of additional industrial lands, the 60,000 acres within the city limits of the seven cities are more than adequate. Even allowing for 8 acres of other types of development for each 1 acre of industrial use the 60,000 acres could supply a large part of the future need for industrial land. It should be noted, however, that a part of the 60,000 acres is within the study area and is subject to possible flooding.

By far the larger part of the open land in the County is located in the unincorporated portions. Not all of this land is suited to use for residential or related uses. Even less is suited to industrial use. If as much as 5 percent had characteristics of terrain and location which made it suitable for industrial development, there would be almost 35,000 acres in the unincorporated parts of the County available to supply all or a part of the new land needed.

4. Land Use in the Baylands Study Area

Table 10 shows an approximate distribution of the land in the study area by land use types. Of the total of almost 20,000 acres, approximately 2000 is in developed uses, including almost 900 devoted to industry, and 4200 acres are in agricultural use or are classified urban vacant. The remainder of the area consists of salt ponds, marshlands, and the Bay.

As was indicated earlier, there are some 847,000 acres in Santa Clara County, with about 752,000 subject to property taxation. The study area includes about 20,000 acres of land and water, or about 2.5 percent of the total County acreage. Most of the lands in the study area are subject to taxation, so they can be related to assessed lands in the County. Total countywide assessed lands and study area lands are compared in Table 11.

The study area includes less than one percent of the residential land in the County, but accounts for some 30 percent of all land in transportation or utility use. About one acre of each 12 acres of industrial land in the County is found in the study area. Commercial and agricultural lands in the area are below average, while lands in public use and in the urban vacant category are above average but are not a large part of the County total. The "other" category is equal to almost 11 percent of the County total. This class includes marshes, salt ponds, and water areas.

Only portions of the study area have been developed. If more of it were developed, and the total acreage were to be protected by levees, about 10 years of growth

TABLE 10

1967 LAND USE IN THE STUDY AREA, BY MAJOR CLASSES BELOW THE 6.5 CONTOUR

LAND USE	ACRES	%
Residential	427	2.1
Industrial	857	4.5
Transportation, Utilities, etc.	434	2.2
Commercial	70	.4
Public and Related	201	1.0
Sub-Total, Developed	**1,989**	**10.2**
Urban, Vacant	961	4.9
Agricultural	3,249	16.4
Sub-Total	**4,210**	**21.3**
Open Space	4	--
March	1,916	9.7
Extractive	9,913	50.0
Bay Water	1,760	8.9
Sub-Total	**13,593**	**68.5**
Total	**19,792**	**100.0**

Source: Estimated from area maps, assessors' records, and County Planning Department maps.

in the County could be accommodated there. However, with about one-third of the area, or 5,800 acres, not provided with protection under any alternative plan considered, (see Chapter IX), and about 2,000 acres already in use, no more than six years of growth could be contained in the area. Consequently, land must be utilized elsewhere in the County to accommodate future growth, regardless of what is done in the study area.

TABLE 11

LAND USE IN THE BAYLANDS STUDY AREA, COMPARED WITH COUNTYWIDE LAND USE, BY CLASSIFICATION, 1967

Land Classification	Assessed Lands County Total	Lands in Study Area	Percentage of Study Area to County
Residential	48,175	437	.9
Industrial	6,272	857	8.2
Transportation, Utilities	1,422	434	30.5
Commercial	4,329	70	1.6
Public	7,087	201	2.8
Urban, Vacant	15,700	961	6.1
Agricultural	542,837	3,249	.6
Other	126,469	13,593	10.7
TOTAL	**752,290**	**19,792**	**2.6**

Sources: Santa Clara County Planning Department, distribution of lands subject to assessment. Lands in study area from special tabulations based on census and assessor's data and Planning Department maps.

CHAPTER VII

ECOLOGY OF THE BAYLANDS

As noted in the last chapter, a distinctive aspect of the Baylands study area is that more than half of the total area that is susceptible to salt water flooding consists of salt ponds, marshlands or open water. The unique ecology of the Baylands and its significance in the consideration of alternative flood protection plans is discussed in this chapter.

A. THE ECOLOGICAL INVENTORY

The Baylands study areas encompasses several different types of wildlife habitat. A simple but ecologically erroneous system has been to categorize the habitats as either salt ponds, salt marshes, tidal flats, uplands, or open water. The errror is that these categories are far too simple; they are so general they imply an ecological homogeneity within each category that, in reality, does not exist. For example, the category "open water" fails to distinguish between the shallow, exposed waters of the South Bay, the protected tidal currents of the creek and slough estuaries, and the less saline, warmer and sluggish upper reaches of these creeks and sloughs. All of these are "open water" but their ecological constituents are widely differing.

A concept somewhat more difficult to grasp because of its unfamiliarity, but more valid ecologically, is to categorize each of the various sectors of the study area into a "biocoenose", defined as the "the aggregate of interacting organisms living together in a particular, discrete community containing the elements of a balanced ecosystem". Within these biocoenoses will be found the various habitats which the wildlife of the Baylands occupy and the niches in which they function. In order to permit some comparison with earlier studies by official agencies which did use the over-simplified categories, the biocoenoses discussed will be grouped, to the extent possible, with the simple category headings. Classification overlaps will occur.

1. Tidal Flats

"Tidal flats" are generally understood to be the zones of apparently barren mud, muck, or sand exposed at low tide. The upper boundary is indicated by the edge of emergent vegetation or wave-cut bank. The acreage of this mud flat varies not only within the 24-hour tidal cycle, but also with the monthly or seasonal tidal cycles and floods. Within the South Bay itself, the presently exposed mud flats are probably only slightly smaller than they were in pre-history. Generally, the levees and fills of the Baylands have been located along the upper boundaries. The mud flats of the South Bay proper are still about where they were and, due to increased siltation and deposition, the flats exposed at low tide extend even farther out into the Bay than in pre-history. However, significant loss of mud flats has occurred along the banks and channels of dredged, straightened, and blocked sloughs and tidal creeks. Some tidal sloughs have been completely obliterated. Goose Slough, that once existed just east of Alviso Slough, is a typical example. Others, like Stevens Creek, have had a meandering channel dredged to a straight drainage gut that contains a mere "eyebrow" of tidal mud flat and salt marsh vegetative edge. Other major drainages in the Baylands--Coyote Creek, Alviso Slough, and Guadalupe Slough--have been beheaded by fresh water impoundments, usually at the 10- to 12-foot contour; and the brackish intergrades of water, fish passage, and biotic energy flows are interrupted at these points.

The environmental importance of tidal mud flats has been thoroughly established. Primal productivity for the mud flats of one South Bay slough has been calculated at 2,000 pounds per surface acre. In the absence of pollutants and excessive sedimentation the productivity undoubtedly could increase. The phyto-plankton--the sessile micro-organisms, the algae and other inconspicuous vegetative forms of the complex biocoenoses of the tidal edges--serve as an interdependent biochemical factory releasing oxygen into the air and water via photosynthetic processes, absorbing carbon dioxide and hydrogen sulfides, and fixing the carbonates, nitrates, and phosphates.

a. West Side Flats Open to Bay

Three distinct types of tidal flats have been discerned in the study area. The first is found facing the open Bay from the Palo Alto Yacht Harbor to the Bay curve beyond the Stevens Creek-Whisman Slough estuary, where the mud flat has its upper boundary against an eroding bank of *Salicornia* sod or heavy wave-eroded levees. Here, the mud flats are exposed to strongly ripping winds and tide currents, and the soilwater interface tends to be unstable. Sea lettuce (*Ulva* sp., a salt-water alga) is found here, sheltering a host of marine invertebrates. Small crabs, polychaete worms, annelids, and bay mussels are found attached to clumps of eroded banks or buried driftwood, which also support numerous barnacles and their symbionts. The mud in this area is generally stiffer and less soupy than in the estuary mouths or tidal slough flats. Burrowing clams and, in deeper waters, oysters can still be found despite the Bay pollution that ended the commercial oyster harvest here. This tidal mud flat does not attract large bird populations; the area is too exposed to wind and wave, and the foraging is not as good as in the more protected estuaries. The bulk of the bird life in the sector from the Palo Alto Yacht Harbor to the Stevens Creek estuary is to be found in the Palo Alto Marshland Preserve and the protected ponds of Charleston Slough, not on the coastal tide flats.

b. Estuarine Flats

A second type of tidal complex is formed at the estuaries of Guadalupe Slough, Alviso Slough, and Coyote Creek. These three drainages, conjoining Mowry Slough, which lies outside the study area near Fremont but is an important factor in the Baylands ecosystems, are in close proximity at the southern extremity of the Bay, and they create a key bastion in the wildlife environment of all the Baylands. The tidal mud flats of these locations are soft, lightbrown mucks which, in the absence of pollution, are teeming with a varied population of micro-organisms and invertebrates. Oxygen exchange is carried on here, too, during exposures at low tides. Unlike the tidal flats of the westerly sector, the soils here grade into the *Spartina* zone (*Spartina foliosa*, saltmarsh cord-grass--a salt-tolerant, land-stabilizing plant) and the higher marsh vegetation. The demarcation is determined by the inundation tolerance of *Spartina*, not by the substrata. The estuarine flats provide a favored low-tide food niche for hosts of foraging shorebirds who probe the exposed muck for worms, snails, and other invertebrates. The South Bay provides vital nesting habitat for many shorebirds; the estuarine mud flats provide a critical food niche. The abundance of shorebirds here only emphasizes, by contrast, how scarce they have become elsewhere in coastal California, as tidal flats and bays have disappeared.

c. Tidal Slough Flats

The third type of tidal flat complex consists of the mud flats that are exposed at low tide in the meandering sloughs. They are particularly valuable because of their exaggerated "edge effect" and the amount of disperson they provide for the organisms which find habitat and niches here. Puddle-ducks--mallard, shoveller and teal--forage over the flats at low tide and find handy escape or brood cover in the *Spartina* or tule stands. In the brackish water sectors of the slough flats colonizing clones of alkali bulrush, *Scirpus robostus,* have become established, and provide one of the few high-quality waterfowl food plants in the Baylands. Raccoon tracks are often found on these tidal flats. Here, too, the shorebirds forage along the edge of the receding tides. Unfortunately, much of this vital foraging area is still polluted from chemical wastes, cannery residues, and old sewage outfalls. Despite the legislation, litigation, and general outcry of the last few years, the sloughs are not yet cleaned up, although they are no longer the noxious open sewer lines of our very recent past.

2. Salt Marshes

Most colored maps of the Baylands show a complex of green marshlands adjacent to the sloughs and the community of Alviso, and bordering many of the salt ponds. In most instances, except for the "eyebrows" along the sloughs, these lush green marshlands do not now exist. Within the Santa Clara County Baylands there is no salt marsh of the extent or importance to wildlife comparable to Greco and Bair Islands, located to the northwest along the Redwood City Bayfront, or the Mowry Slough complex on the northeast side of the Bay. Only the minor marshes of the Palo Alto Marshland Preserve, the Yacht Harbor overflow, the Charleston Slough remain as important segments of the *Salicornia* marshland that once dominated the South Bay landscape. The so-called "New Chicago" tract at Alviso has had half its acreage circumvallated by a new railroad fill and switch track and, consequently, is dried and converted to upland weeds. It is a habitat for jackrabbits, mice, voles, song sparrows, and goldfinches which are all valuable wildlife but not marshland forms. The remainder of the tract is transitional uplands and high marsh, subject to overflow but not, in its present state, productive for wildlife. Only the tidal slough "eyebrows" have a significant environmental importance as tidal marshlands to the wildfowl, waterbirds, and marshland animals that are of major public interest.

a. Salicornia Tidal Marsh

The Palo Alto Marshland Preserve contains approximately 80 acres of pickleweed marsh, the Yacht Harbor about 25, and Charleston Slough has less than 60 acres. Edging the Bay coast before Salt Ponds 1 and 2, another 25 to 30 acres of eroding tidal marsh exist. In these four areas a total of approximately 200 acres is all that remains of this biocoenose in the Santa Clara County Baylands.

The environmental value of this *Salicornia* tidal marshland is a subject of debate among biologists and professional or lay conservationists, as well as between engineers, community planners, and developers. The attributed values range from "an irreplaceable natural resource and a priceless national heritage" to "a noxious, mosquito-producing and potentially epidemic vector area that should be drained for proper human use". The choice of terms varies with the choice of social and economic goals; all the rhetoric contains some elements of truth.

Objectively, the question must be asked as to how a tidal salt marsh fits into the environmental framework, and, specifically, what is the ecological value and the probable fate of the remaining 200 acres of Baylands *Salicornia* marshes?

Typically, a *salicornia* tidal marsh as found in San Francisco Bay consists of two major plant associations. In the deeper water, the buffer between the tidal mud flats and the higher tidelands, there lies a band of grey-green emergent vegetation that superficially resembles a stand of ripe wheat. This is saltmarsh cord-grass, *Spartina foliosa*, a sod- and marsh-building salt-tolerant plant that grows only in such very wet, mucky sites. Although the plant can stand fairly prolonged inundation, as in spring floods, dehydration quickly kills it. Despite its apparent wealth of seeds, *Spartina* has little food value for birds or other wildlife, although the plant provides habitat and foraging niches for many organisms, and its decayed vegetation contributes bountifully to the basic productivity of the food web. The belt of saltmarsh cord-grass extends for a few feet up to several yards inland, depending on the shoreline gradient.

An extremely valuable but inadequately recognized feature of the cord-grass zone is the strand lines of driftwood and other flotsam. Tide pools and water pockets are formed by wave wash around these rotting timbers and trash. Myriads of scuds (amphipod crustaceans) provide a food base for larger forms foraging along the strand line. Aquatic animals, including fish, forage when the strand is at flood tide; when the tide recedes, the terrestrial animals--rats, mice, raccoons, shorebirds, and wading birds--forage along this natural cafeteria line. This intricate food web is based on the primal productivity of the phyto- and zoo-plankton in the waters or stranded on the mud of this tidal flat and marshland.

Above the cord-grass association, at about the median of the daily tides, begins the pickleweed association. Pickleweed *(Salicornia ambigua*, var. *pacifica* according to some writers) is a bright green, succulent, salt-tolerant, low growing shrub-like herb. The genus *Salicornia* is ubiquitous throughout the world in oceanic and saline marshes. *Salicornia* was known to the Crusaders in the Holy Land. They collected and seethed the plant with vinegar and salt to prepare a prized dish called "samphire". They must have been very hundry, for few animals find any food value in this plant, although occasional trace amounts are found in the gizzards of the shoveller ducks and widgeon. Mainly, the *Salicornia* association provides habitat for multitudes of spiders and insects. Among the most common are *Collembolans* or springtails, a kind of small gnat. The salt marsh mosquito, *Culex* sp., was once a problem; the insecticides used to control the mosquito are now the environmental problem. The plant is sometimes parasitized by the bright orange dodder *(Cuscuta* sp.), a plant pest that occasionally also invades domestic farm crops such as hay.

Progressing higher from the strand line into the pickleweed, primal productivity lessens rapidly. A few stranded diatoms and other plankton coat the intersticial mud surfaces. The pickleweed grows higher and shades the mud surfaces entirely. A secondary strand line from the monthly high tides is encountered; on this, an occasional clone of brass-buttons, *Cotula corono-pifolia*, takes root in a rotting crevice. Brass buttons is a pretty, succulent composite with a small yellow flower. It will not tolerate the soil salt concentrations that are acceptable to pickleweed. The plant is sought after as forage by mallards, widgeon and coot.

In the Baylands the *Salicornia* tidal marsh provides a habitat for the red-bellied harvest mouse *(Reithrodontomys raviventris)*, a seldom-found rodent that is endangered not only by loss of its pickleweed habitat but also by competion with house mice *(Mus musculus)* that are far more common in the tidal marsh. The house mouse is omnivorous; when floods or seasonal high tides drive the mammals from the marsh, the house mouse moves to garbage dumps or human habitations; the harvest mouse, essentially a seedeater, moves to high ground and goes hungry, or forages in dangerous territory. In one trap line in a North Bay salt marsh the ratio of house mice to harvest mice taken was 20 to 1.

Another denizen restricted to the tidal marshlands is the clapper rail, *Rallus longirostris.* These shy, secretive birds, never numerous, are severely threatened as a species by any further reduction of their habitat. The only other birds whose habitat and forage niches are found entirely in the tidal *Salicornia* marshes are certain groups of song sparrows who appear to spend their entire lives in the salt marsh. Whether these are a genetically or even morphologically disticnt strain has not yet been determined. Song sparrows, as a species, are one of the most widespread and ubiquitous of all the passerine or perching birds. Many other animals--birds, mammals, and invertebrates--find a seasonal habitat or a forage niche in the tidal marshes.

The function of the *Salicornia* tidal marsh in primal productivity, its role in purifying the atmosphere, and its provision of an unbroken evergreen belt that delights the human eye, may not necessarily argue for the restoration of the lost thousands of *Salicornia* acres; but most certainly the scale is tipped toward no further reduction of the remaining acreage.

b. Tidal Slough "Eyebrows"

The colorful and descriptive term "eyebrows" is given to the tidal vegetation that fringes the sloughs of the Baylands. These "eyebrows" show vegetative zonation that clearly defines the varying limits of the ebbs and flows of the diurnal tides, the monthly high tides, and, in some sites, even the equinoctial tides, although this third zone is largely obscured now by the inboard levee system that rings the Bay. A typical tidal zonation profile is shown on Plate 5. The upper limit of the diurnal tide zone is marked by the upper limit of *Spartina* or, if the slope is gentle, by a rim of *Salicornia.* In the highly saline mouth of the slough estuary, saltgrass *(Distichlis spicata)* may be found in the monthly high-tidal zone; and above this point, higher on the levee banks, gum-plant *(Grindelia humilis)*--a pungent, sticky sunflower--is encountered. *Grindelia* is a valuable forage plant for many insects, such as bees and butterflies, as well as seed-eating birds. Coarser, shrubbier stands of both pickleweed and saltgrass will be found here, as well as Coyote brush, *Baccharis pilularis.* In the Baylands, levees topped with roads border all the sloughs and creeks, and the roadsides support a varied assemblage of more or less salt-tolerant grasses and weeds. These levee associations are detailed in Section 3.a. of this chapter.

Farther upstream in the sloughs, the tidal zonation remains visible but the indicating plants change as the water becomes less saline due to fresh water dilution. The zone of *Spartina* may persist until the stream salinities drop below 20,000 parts per million (PPM). (Sea water is approximately 32,000 PPM.) California bulrush *(Scirpus californicus)* and tule *(Scirpus acutus)* begin to appear and may compete enough to displace *Spartina.*

This vegetative usurpation is seldom seen in the Baylands within the brackish water zones, since all of the sloughs are weired a short distance above their estuaries and, of course, are entirely fresh water above the weirs. The vegetative compositions of higher tidal zones are similar to those described earlier, although a greater variety of flowering plants and grasses may appear as salinity stresses decrease.

As habitat or niches for resident wildlife population--avian, terrestrial, and aquatic--the tidal slough "eyebrows" have the highest ecological value of any site in the Baylands; they outweigh the *Salicornia* flats in both the population size and species variety. The "eyebrows" do not attain the primal productivity of the tidal mud flats, but they support a far greater variety of the larger terrestrial organisms. Only the primary intake salt ponds attract more migratory waterfowl than the sloughs, but the sloughs also function as high quality wildlife habitat throughout the year, not merely during migration.

The only truly balanced biocoenose that still remains in the Baylands is the tidal slough. Here all the living elements -the producers, comsumers, reducers, and transformers--interact with the non-living physical world in a relatively well-balanced and stable community that would continue to function as a discrete ecological entity even if the rest of the Baylands were smothered under asphalt. But without the tidal sloughs the other biocoenoses of the Baylands--the mud flats, the salt ponds, and the uplands--would become sterile. All of the terrestrial mammals of the Baylands (the harbor seal is classed as aquatic) are vitally dependent upon the slough tidal flats and levees for at least a segment of their existence. Even the harvest mouse must flee to high ground at extreme high tides; and the rabbits, mice, rats, and voles find both escape cover and forage here. The predatory mammals--skunks, raccoons, weasels, and opossums--nest, whelp, forage, and hide in this habitat. The slough tules provide nesting cover for red-wing blackbirds, coots, and marsh wrens. Some puddle ducks--teal, mallard, and occasionally gadwall or pintail--nest in the slough saltgrass, *Salicornia,* or weed cover, and forage on the alkali bulrush, brass buttons, and saltbush *(Atriplex* spp.) found here.

3. Salt Ponds

In Chapter III the origin of the salt ponds was described briefly and the somewhat piecemeal pattern of their development in the South Bay was noted. The complete picture of the salinity gradients of the ponds and their concomitant biotic compositions has not been clearly delineated, for such detailed analyses are not needed for the purpose of this report, but sufficient information exists to permit a valid ecological evaluation.

A detailed description of the total complex of the Leslie Salt Ponds operations in South San Francisco Bay lies beyond the area of concern of this study. However, of major pertinence to the ecological evaluations of this study is the clear understanding of the role played in the environment by the varying salinities and juxtaposition of the salt ponds in the Baylands.

Plate 6 shows the sequence of passage of Bay salt waters from their primary intake points, initially at Charleston Slough, around the southeast curve of the lower Bay, to the delivery by pump from Pond A-19 over Coyote Creek into the Alameda County sequence of ponds that lead to the final harvest ponds at Newark. No scientifically detailed ecological analysis of this particular sequence has been made, but enough peripheral information exists for a general evaluation, despite the lack of correlative data on salinities and biomass in the various ponds.

Bay water at a salinity of up to 32,000 PPM is drawn through an intake near the mouth of Charleston Slough. This slough and the hundred acres of land immediately north are now part of the Palo Alto Marshland Preserve. Leslie Salt Ponds 1 and 2 are leased to private waterfowling groups; about 20 or 30 platform blinds are located in these ponds. During a field inspection in October 1971, about twenty to thirty thousand waterfowl, mainly pintail, were concentrated in the sanctuary. A few ducks were also observed around the shooting blinds, since it was an off-shoot day.

The water passes from Pond 1 to Pond 2. Pond 2 is divided by the Stevens Creek channel. Facing the Bay before Pond 2 east of Stevens Creek East is Pond B-1; new Bay water is taken in here again and is combined in Pond B-2 with earlier water from Ponds 1 and 2, and is then siphoned from two locations into Pond 3. A few blinds are located in Pond 2 west; the east pond, along with Ponds B-1 and B-2, contain about sixty blinds. These ponds appear to be heavily hunted. Elaborate spreads of decoys are set around the blinds in use, and duck boats are chained to small one- or two-board docks. To avoid disturbing the hunting, lessees' ponds were not inspected on the Wednesday, Saturday, or Sunday shooting days. No recent statistical information is availalbe for South Bay duck clubs. For many reasons--social pressures by anti-gun or rabid game preservationist groups, furious "duck widows" and curious IRS tax investigators, state and federal game law enforcement officers, vandals who break into clubs and blinds, and poachers who shoot their ducks--duck club hunters are wary and seldom respond to questions from strangers. The little information that is available is derived from data obtained by Wildlife Associates many years ago, during several years of close work with duck clubs. The actual number of South Bay residents who hunt waterfowl on a salt pond can be inferred as follows.

Approximately 100 blinds are built in the ponds between Charleston Slough and Guadalupe Slough. About 70 of these are operative. No more than half of the usable blinds will be occupied on any shoot day. Since, on the average, two hunters share a blind, this sector of the marsh on a typical shoot day will have about 70 hunters on it. Shoot days are Wednesday, Saturday, and Sunday--three days each week--totalling about 200 hunter-days per week in the ponds described, or about 2,000 to 2,400 hunter-days per season. Shooting is not very successful in the South Bay; the hunters may average 2.5 ducks per day, comprising a total of 5,000 to 6,000 waterfowl harvested in this section of the South Bay waterfowl marsh. Waterfowling crippling loss is conservatively estimated at 1:1; one duck bagged to another duck shot but not recovered. The waterfowl harvest for this segment of the salt ponds for the total season can be judged to be around 10,000 to 12,000 ducks. It must be recognized that this projected kill figure is subject to wide variation, probably downward, depending on the vagaries of the weather.

Since economic values of land are often projected upon expenditures, some insight into the dollar value of this harvest is pertinent. In 1962, a duck in the bag was estimated by the United States Fish and Wildlife Service to cost $8.16. Inflation probably brings that cost to at least $12.00 in 1971. The dollar value of waterfowling in this sector of marsh, then, can be calculated to range from $60,000 to $70,000. J. E. Skinner (in *Fish and Wildlife Resources of the San Francisco Bay Area,* 1962, p. 147) attributed a gross expenditure of seven million dollars in the total San Francisco Bay complex, including Grizzly Island and the Suisun and Napa Marshes. The point of the foregoing digression into waterfowling and economics is to emphasize the effect of an ecological impact, i.e., dilution of salt concentrations with an intake of bay water, on wildlife recreation goals.

From Ponds B-2 the waters pass to Pond 3 and then, via a canal across the Sunnyvale Sewer Pond, to Pond A-4. At the eastern extremity Pond A-4 transmits to A-5, via pump over Guadalupe Slough and through a small service pond. A-5 is a pond of high concentration and receives comparatively little waterfowl use. Salt encrusts the pond bottom. The pond is large, 600 to 700 acres, and the prevailing westerly winds whip up sizable waves. On levee banks and roads, where these waves break, vegetation is very sparse, restricted to only the most salt tolerant forms: a small ice-plant or glass-wort, *Mesembryanthemum* sp., and struggling sprigs of *Salicornia*, as shown on Plate 7. Seasonally, the waters of Pond A-5 are pumped into A-6 and then to A-7 and A-8, where the brine is concentrated further. From A-7 the ponded waters pass to A-8, and some water is diverted to another small service pond, subleased for brine shrimp harvest and the caging of bait fish (sculpins, so-called "bull-heads"). Brine shrimp harvest and the marketing of bait fish are, along with waterfowling leases, the three subsidiary commercial concessions which have been found to be compatible with salt production. All three of these apparently have been profitable but somewhat haphazard and small- scale. The multiple-use potential of these pond complexes on a substained yield basis has never been really recognized.

From A-8 the brine is pumped via pipeline across Alviso Slough to A-11. At the mouth of Alviso Slough the third Bay water intake is located. Bay water enters Pond A-9, flows by gravity conduit to A-10, and mixes in A-11 with the highly concentrated effluent from A-8. The now diluted brine passes from A-11 to A-12, then to A-13. A-14 is a storage control pond and may or may not be used in a cycle. From A-13 the water is lifted to A-15 by pump, is siphoned to A-16 and then to A-17, is boosted across Artesian Slough to A-18, is pipelined across Coyote Creek to A-19, and out of Santa Clara County. From A-19 to A-20 to A-21, around the Drawbridge Duck Clubs, the water is again pumped through a pipeline into the large ponds of the Alameda County system.

This is an intricate and fascinating system, a part of the largest solar evaporation plant complex in the world, and a colorful and important segment of the industrial community of the San Francisco Bay Region.

Even if the data were available, a pond-by-pond recital of salinities and ecological entities would be tedious and pointless. The important concept to grasp is that along the course of the movement of Bay waters in the salt ponds from intake points to concentration ponds, the salinities vary. Certain organisms have certain salt tolerances, or even preferences. Each pond, even up to the salt collecting stage, has an assemblage of living things finding a habitat or a niche in the water or on the levees and dikes.

Waterfowl concentrations on the intake ponds have been cited earlier, such as those observed on Ponds 1, 2, B-1 and B-2. Observations on intake Ponds A-9 and A-10 in late September 1971 were particularly significant. The first large fall concentration of migratory ducks, mainly pintail, was noted there at that time, an estimated twenty-five to thirty thousand ducks on the water and levee banks. Just across the levee, Ponds A-11 and A-12 did not have a duck on them. These are the ponds that receive concentrated brines from Pond A-8. Pond A-8 had very few ducks, but did have numerous shorebirds gulls, terns, and a few wading birds, Brine fly larvae and brine shrimp were plentiful in A-8, although they did not reach the countless millions that have been observed in pink windrows in the lime ponds--the intermediate concentrations where calcium sulphate crystallizes out of solution--opposite Redwood City or those north of Mowry Slough.

The importance of "edge effect" is discerned in Ponds A-8 and A-5. Guadalupe Slough meanders along the southwest boundary of Pond A-5. Levee banks and old dike islands in this area provide some of the highest nesting concentration for avocets, black-necked stilts, killdeer, and other shore-birds in the South Bay. The reasons for this nesting concentration probably lie in the juxtaposition of tidal slough mud flats, which are used for daily foraging foray, plus escape cover offered by the "eyebrows", and the stable shallow water levels of the salt ponds. Nests on little, muddy islets or on broken dikes are not swamped by tides or unseasonable floods, and mammalian predation and human vandalism is light, since the soft muds are impassable on foot. Most of the more voracious avian predators, the gulls, find better pickings around the local garbage dumps. Thus, there is a high productivity of shorebirds in this vicinity.

In addition to shorebirds, nesting colonies of black and Caspian terns are found on Pond A-8. At one time, ten or twelve years ago, the Gordon Knapp "Duck-a-Day" duck club, located at the extreme end of Pond A-6 between the estuaries of Guadalupe and Alviso Sloughs, used to maintain a managed 17-acre fresh-water marsh the year round. The water was pumped from a deep well on the property. At that time many local ducks--mallard, teal and pintail--nested in the fresh-water ponds. This club of about eight to ten members used to bag over a thousand ducks a season. The fresh-water ponds were teeming with succeeding generations of micro-organisms and tiny invertebrates which attracted hundreds of phalaropes, sandpipers, and other shore-birds. The ponds were ringed with alkali bulrush, *Scirpus robustus*, the first-rank native waterfowl food. For the past decade, however, the well has been operated only to fill the 17 acres of shooting ponds during the hunting season. Food plants have disappeared from the pond areas, nesting has ceased, and shore-birds or local water-fowl no longer find a year-round haven here. This area is now being acquired by Nature Conservancy, and its wildlife productivity is expected to be enhanced.

A network of power transmission lines interlaces the Bayland salt ponds. These transmission lines add a vertical element to the marsh environment that did not exist in the days of the padres. As with all environmental modifications, the ecological impacts of the power lines have disadvantaged some living things and helped others. These impacts were investigated in the course of an earlier environmental study which presented evidence that transmission lines, contrary to what might be expected, enhance the biotic productivity of the marsh far more than they impair it.

The high tension power lines are supported on steel towers; each of which has four concrete bases about ten feet square. Across the salt ponds the towers are joined by a wooden causeway of two 4-by-12 planks supported at 12-foot intervals by a 4-by-4 trestle. The legs of each trestle set make eight square feet of attachment space available to sessile invertebrates. Encrustations of food-base animals on these trestles vary from barnacles and boring clams in fresher waters to solid masses of brine fly and brine shrimp eggs in lime ponds. Algae, lichens, mosses, and even small flowering plants find lodgement in the pulpy wood of old trestles and planks. The calculated amount of added habitat available to sessile life forms in three miles of transmission line is a full acre. There are many miles of such lines in the South Bay.

A second ecological enhancement is that the cross arms, tower girders, and causeway rails or tower bases often provide roosting sites for water birds. As many as 75 brown pelicans and as many as 600 cormorants have been recorded roosting around the towers during autumn months. The guano on the causeway here may get several inches thick and the power maintenance crews regularly have to scrape the causeway for service access. Many other birds, particularly swallows and wading birds, find foraging roosts around the tower lines. A number of terrestrial invertebrates such as spiders, centipedes, and isopods (pill bugs) find habitat along the causeways and on the towers. These forms would probably not be found in the marsh if the transmission lines were absent.

Another enhancing feature, although trespass is still not permitted on many causeways, is the human recreational access for bird-watching and other nature study. The Pacific Gas & Electric Company causeway at the Palo Alto Natural Science Center is open to the public and is heavily used.

The detrimental ecological impact of which power lines are often accused is destruction of bird life either by electrocution or from collision in flight. These accidents rarely occur in California; the high tension electric power lines of the South Bay are particularly problem-free. No authenticated accounts of electrocution have been recorded from the Baylands. The "hot" conductor cables are at least eight feet apart, even in the lower voltages; the insulator porcelains are in 8- to 10-foot strings; and there is no bird in the Bay Area with a wing span large enough to extend from hot cable to ground contact. Collision may occasionally occur, but careful study indicates that collision with the large-diameter transmission lines seldom occurs, since the line is more visible; and, if collision does occur, it generally bucks the bird away and does not wound or kill, as would collision with the thinner and less visible distribution lines, the relatively low-voltage, wood pole lines common along city streets and county roads. The only records of collision fatality in the Baylands result from a low-voltage line restrung on a now-unused high tension steel tower line through Pond A-6 out to the Knapp Duck Club. This pencil-thin wire regularly hangs up two to three birds each year. Even this grim sight is of slight consequence, considering the tens of thousands of bird flights over, under, and through these wires each year. More ducks are undoubtedly struck by cars on the nearby freeways.

The one detrimental effect of transmission lines which cannot be contested is "visual pollution" in the sight of those people who dislike looking at power lines. To most people--those who realize that the use of a toaster, a TV, or a reading light requires that electricity must come from somewhere--visual pollution by most transmission lines is minimal. Compared with a line of steel giants striding across a marsh out of the foothills, far more people object to the welter of distribution lines in city streets.

a. Salt Pond Levees

Considerable detail has already been presented about the salt pond levees and dikes. A series of cross sectional diagrams, Plates 5, 7, and 8, illustrate the various types of vegetation which may be found. Reference has been made to the effect of wave action and salt spray. Generally, the luxuriance and species variety of vegetation found on the dikes and levees is closely correlated with the salinity level in the adjoining ponds. High pond salinities mean restricted vegetation. Exceptions may be found on levees or dikes which are high and broad enough to be above the range of salt spray and wave runup; and long enough established so that years of winter rains have leached at least some of the salt from the surface soil layers. Here, typical upland grasses and roadside weeds will grow, and a more varied habitat will attract some of the upland birds and insects and even a few mammals. For example, the east bank of Stevens Creek, near the cross-dike B-1/B-1 Pond 2, is about fifteen feet high and approximately sixty feet wide at the base. The crown is wide enough to support a strip of grass several feet wide and the inside is broad and gently sloping. (See Plate 8.) A colony of California ground squirrels, *(Citellus beecheyi)* thrives here; at least five to ten foraging individuals have been seen on each visit. This is an isolated little colony, about a half mile from the nearest possible squirrel habitat. The colony's burrows extend about forty yards along the levee and are all on the inside bank; no burrows are found on the tidal side, even at a height above the monthly flood levels.

However, most of the levees or inside dikes fail to attain leaching height and, except along the tidal sloughs, the vegetation is restricted to those few species indicated on the diagrams. Wave and rainfall erosion is, of course, severe on mud dikes which are not stabilized or protected by vegetation, and the salt company faces constant maintenance.

4. "Uplands"

The term "uplands" has been used in official environmental statements by federal and state agencies, and consequently has been adopted as a valid habitat category by local Baylands study groups and planning commissions. Unfortunately, in the Baylands this useful word has no ecological reality; it does not define any discrete habitat nor any specific biocoenose. Under the category "uplands" the agencies have grouped such diverse situations as overflow floodplains, partially "developed" tracts and semi-leveled wastelands, or small abandoned enclaves and unofficial dumps, outlying freeway construction sites, sanitary fills, sewage treatment plant sites (present and future), and even some true upland farm and pasture lands.

Ecological distinctions obviously exist between an elevated sanitary fill (reeking of smoke and waste, riddled by ground squirrels and Norway rats, and dappled with foraging gulls) and an abandoned real estate tract (seasonally inundated, grown to rank grass, thistles, and wild mustard). An environmental impact such as positioning a flood control levee, will elicit a different environmental response from each different "upland" habitat situation. And, as usual, each environmental response will be to the advantage of some living creatures and to the disadvantage of others associated with each habitat.

A fully detailed description of each "upland" habitat within the Baylands study area would be tediously unnecessary. Some areas, however, should be described in this ecological inventory.

a. "New Chicago" and Similar Wastelands

"New Chicago" consists of land reclaimed from a one-time tidal marsh as a real estate tract during one of the early local land booms.The boom burst and eventually the tax-delinquent land became County property. The shadowy squares of once-graded streets and lot boundaries can still be seen on aerial photos and on the ground. Although the land is ostensibly behind levees, there are culverts and breaks; all of it is subject to inundation at exceptional flood tide, although most of the time this is a drought stricken weed-overgrown wasteland. A few years ago a spur line of the Southern Pacific circumvallated the southeast sector of "New Chicago" to serve the San Jose-Santa Clara Water Pollution Control Plant. That portion of the tract lying north of the tracks lies at a slightly lower elevation and receives a bit more tidal flooding. In addition, secondary stage sewage effluent from the Alviso treatment plant is diverted into this sump. A tule cattail bog, fairly odorous and not very productive, has resulted. The northern marshy sector has been included in the national wildlife preserve.

Any conservationist will agree that, in this era of vanishing wetlands, any tract of marshland, however small, which can be perpetuated is ecologically valuable. But beyond mere wetlands preservation, the goal should be to build a truly productive, managed marsh as described in Section C below.

The tract of wasteland in the Palo Alto floodplain which lies between the west bank of Charleston Slough and the Mayfield Slough levee, and northeast of the Bayshore Freeway, is in many respects similar to the "New Chicago" tract. This area of relapsed "developed" tract land, approximately 300 acres in size, has been designated by the City of Palo Alto as a marshland preserve. Aside from its being posted as a preserve, nothing has been done to manage or encourage wildlife on the area. Meandering automobile trails rut the area. Water is close to the surface here, and mud sinks and chuck holes show by boards, sacks, and shovel marks that unlucky trespassers or nature lovers have had to excavate their bogged cars. Charleston Slough and the water impoundments adjacent to this property rafted sizable numbers of waterfowl and waterbirds during the October 1971 inspections. The dry ground within the preserve offered very sparse evidence of wildlife use. A few song sparrows, a couple of meadowlarks, one shrike, a flight of red-winged blackbirds, and two doves were all the terrestrial bird life noted during the field trips. Although two jackrabbits were put up, the numbers of rabbit pellets and rodent droppings found indicate a relatively modest mammal population. No ground squirrels or their burrows were noted within the preserve, but these rodents may occur; all of the higher ground was not investigated. Levees and banks near the sewage disposal plant and sanitary fill had ground squirrels.

Vegetation within the preserve is not particularly high quality wildlife food or cover. Saltgrass is common; wetter areas near the Bay front have rabbitsfoot grass

(Polypogon monspe liensis), and Italian ryegrass *(Lolium multiflorum)*, as well as many foxtails *(Hordeum sp* and *Bromus spp)*, mustard *(Brassica campestris)*, star thistle *(Centaurea solstitialis)*, docks *(Rumex spp)*, and saltbush *(Atriplex spp)* among the larger weed species. These are all plants commonly found in such abandoned, dry, saline areas.

Although wildlife use was light at the time of inspection, human use, despite the "no trespass, no access" posting, was moderately heavy and constant. Motorcyclists, as usual in suburban wastelands, were ever popping and roaring in dust clouds around the preserve. Several people were walking their dogs and, twice, sweat-suited joggers were encountered. The preserve, of course, had its customary and anticipated litter of plastic bags, popbottles, beer cans, and the other indicators that here humans had enjoyed recreation close to nature.

b. Sanitary Fill Sites

Sanitary fills near Coyote Creek, Alviso, Sunnyvale, Mountain View, and Palo Alto were visited and checked to note methods of fill, evidences of animal activity, signs of environmental impact, such as seepage into drainages, or obvious potential pollution. Professional ecologists confess to a certain philosophical bias when viewing a sanitary fill. It is an offense to ecological balance to smother and obliterate a vitally important and productive living segment of an ecosystem, such as a marsh, under a dead burden of human trash. Further, the original offense is self-defeating since, eventually, one runs out of marsh. Then what can be done with the garbage? And what can be done with sanitary fill sites in an earthquake area where health, safety, and building codes do not permit structural development on such sites? It has been proposed, and in some cases planned, that sanitary fill sites be used for the development of city and regional parks. Thus, the problem is pertinent to the terrestrial environment concerns of the study.

All the impacts of a sanitary fill are not environmentally degrading. Many wildlife creatures garner a living from a fill. The hordes of gulls foraging in the new fill are commonplace. Shorebirds, such as killdeer, often find nesting sites here, and horned larks occasionally flock. Ground squirrels, Norway rats, house mice, and the nocturnal mammalian scavengers--raccoons, opossums, and skunks--and noctural predators--weasels, feral housecats, barn owls, and great horned owls--forage here. In the dark silences of the night a garbage dump is a scurrying field of combat, small screams and little deaths. A sanitary fill, of course, is never a balanced ecosystem; vegetation cannot find a foothold in an active fill site. But the fill does contribute a supporting food niche to adjacent habitats.

One of the detrimental impacts of the fills is water seepage from rainfall leaching through the fill; or flood-leaching if the fill boundary abuts a flood or tidal zone, as some do. The fill may contain substances which provide deleterious leachates, which can range from being a simple chemically imbalanced fluid, to one highly organic and biologically dangerous, to a leachate of lethal chemicals. It has been observed that water in the drainage ditches in the vicinity of every fill site was contaminated. Many ditches were scummed with oil, a couple were choked with algae, a possible effect of organic leachate; the large drainage ditch between the Mountain View sanitary fill site and Salt Pond No. 2 was scummed with red-brown algae and iron sulfides. In addition, the canal was also filled with an assortment of tires, auto parts, and bedsprings.

Besides the actual chemical or organic pollution of the environment, fills generally smell bad and are unsightly. There may be little to do about the smell except to stay upwind, but the visual pollution can be screened by trees and landscaping.

c. Streamside Levees and Banks

This section of "uplands" is concerned with the meager amount of freshwater riparian habitat which still exists in the Baylands. This habitat is as important to the terrestrial wildlife environment as are the tidal sloughs. Within the study area only two segments still remain.

The best riparian development investigated is that along the banks of Coyote Creek, from the bridge on Route 237, downstream for two miles, to the creek weir opposite the Milpitas Sewage Disposal Plant. The stream is entirely fresh water, permanently flowing and draining over the weir. Beyond that point, tidal influence is exerted and the creek becomes increasingly saline. Both sides of Coyote Creek in this sector are in fruit orchards; the fresh water in Coyote Creek is pumped over the levee for irrigation.

Vegetation along the creek is dominated by cottonwoods and alders. Blackberry, wild rose, and poison oak are the dominant shrubs or vines. The trees are mature and densely shade the banks, the vine growth is also very heavy. In consequence, the groundcover vegetation is relatively sparse. Mints, a few ferns, and various grasses were noted; but since observations were being made in October, most of the annual flowering forbs were absent or unidentifiable. Certainly, though, this riparian association is lush and productive, and supports a fine variety of birds and mammals. Valley quail, mourning dove, ring-necked pheasant, sparrowhawks, a sharp-shinned hawk, an owl, many different species of perching birds, hummingbirds, and flickers were noted on a single passage down the creek levee. Brush rabbits and, near the saline pasture land, jackrabbits were started. Raccoon droppings, a dead opossum, ground squirrels, and pocket-gopher burrows were found. Moles, shrews, voles, and other small rodents undoubtedly are to be found here. This is some of the last of the producing orchard land remaining in the valley, but the Nimitz Freeway is just a few hundred yards east, and Route 237 is projected for extension eastward as a freeway. The life span of these fruit ranches is closing fast. This sector of riparian habitat may soon be backed by housing tracts or industrial plants.

The other major sector of freshwater riparian habitat remaining in the Baylands is the portion of Guadalupe River from Montague Avenue to Route 237. This section of river lies behind a cyclone fence for much of its length and high steep-sided levees bound it. The levees are barren or sparsely grassed, and in some areas are faced with concrete. But, since the levees are wide apart and the river water is now only a meandering, slow trickle in the channel floor, a lush assemblage of phreatophytes ("water-loving plants") has taken root. Yellow willow cattails, mints, tules, rushes, and horsetails are among the emergent plants; submerged aquatics--pondweeds *(Potamogeton* spp.), milfoils, elodea--were found in deeper pools, and floating duckweeds clustered around the edges. Algal scum is prevalent on many shallow areas or clinging in the black slime of the rivulet bottom. The stream is, of course, somewhat polluted, most visibly with petroleum residue from highway drainages, but the stream supports mosquito fish and some insect larvae.

Many blackbirds, house finches, English sparrows, song sparrows, and a few marsh wrens were seen. One small band of valley quail streamed across the levee bank into an adjacent pear orchard. No mammals were encountered, other than two boys on bicycles and a fuzzy dog. The river channel was humming with bees and glittering dragonflies. Although most of this sector of Guadalupe River is backed up with suburban tracts, cyclone fences, and cleanly cultivated and thoroughly insecticided orchards, there are a couple of 80-acre parcels of raw or abandoned land adjacent to the river levees; these parcels appear to be a portion of the original floodplain that has not yet been drastically modified. The ecological development potential that may exist here is discussed in Section C of this chapter.

d. Upland Flood Plains

Those pasture lands, crop lands, and orchards that lie within the upland flood plain do not fall within the somewhat limited scope of this study. They decisively influence local terrestrial wildlife and the wildlife recreation development of any community must take these adjacent areas into account. Orchards and crops provide not only a source of food and cover for wildlife; wildlife may mean annoyance or financial loss to the rancher; the rancher's insecticides or pest controls may eradicate some of the community's wildlife. Additional detailed study is required before any specific plans are drawn.

5. Open Water

At the beginning of this Section, the problems of defining "open water" were stated. In this study of the Baylands' terrestrial environment, the purely aquatic environment can only receive peripheral attention, although the problems of the waters of South San Francisco Bay are serious and largely unresolved.

"Open water" for purposes of the Baylands study is categorized under four general headings:

a. The fresh waters of the creeks and drainages above the weirs.

b. The sluggish, brackish meanders of the creeks or sloughs immediately below the weirs, leading into the broader tidal slough areas where "eyebrows" appear.

c. The transition to the Bay water salinities of the tidal slough estuaries which are sheltered from the full force of wind and wave.

d. The shallow, open, wind-swept South Bay.

The fresh waters of the creeks have already been briefly discussed. Very little "open" water is found; the larger pools behind the weirs on Guadalupe River are almost completely covered with algal scum and often heavily choked with cattail. Some fish occur. The boys on bicycles reported they sometimes caught "little sunfish and cats" from the ponds. They also hunted frogs and pollywogs. On Coyote Creek, the weir impounds a pool nine feet deep at the gate, about 200 yards long, and about 30 feet wide at its maximum. There were signs of bank-fishing here and there around the pool, but no fishermen were met during the field investigation.

All the tidal sloughs are closely confined and narrow, until below the ten-foot contour. The open waters from that altitude to the estuary throat daily vary widely, from ebb to high tide. At times each day the stream becomes a mere trickle in an expanse of mud. Few of the sloughs are navigable by even small craft for any distance upstream save at high tide, except Alviso for about four miles and Guadalupe for about two miles. This has led to one of the current controversies concerning Baylands development: "to dredge or not to dredge." This issue is discussed in Section C of this chapter. Many fish species forage in the sloughs, although total numbers are probably low. Striped bass, smelt, bottom fish (flounders, sharks, rays), perch, and others forage up the sloughs. Very little angling is reported and no sign of bank fishing was found. Some local pier fishing--mainly youngsters catching smelt--is reported from Alviso. Boat fishing occurs in the estuary mouths and open Bay, but the treacherous channels and tides, and the sudden wind squalls whipping up large waves in this shallow South Bay basin, discourage most of the boaters who head further north into the main part of the Bay for safer, easier waters.

The estuaries are reported to provide fairly good fishing, but angling pressures are light. Striped bass are occasionally taken, although with nowhere near the degree of success reported from the North Bay, the Suisun, or the Delta. Sturgeon are recorded occasionally in the estuaries and South Bay channels, and these waters have an excellent sturgeon potential.

The estuaries provide hauling grounds and whelping sites for a colony of harbor seals, *Phoca vitulina.* These non-migratory aquatic mammals are estimated to number a little over a hundred in the South Bay. Most of this local population lives near Dumbarton Bridge (Calaveras Point); about fifteen are reported near the mouth of Newark Slough; a few individuals were recorded at the Mowry Slough and Coyote Creek estuaries. Although these interesting and harmless mammals are protected by game laws, vandals persist in shooting them on their hauling grounds. The harbor seal population was never large and appears to be dwindling; the wanton slaughter of these amiable mammals is despicable.

Waterfowl and waterbirds can always be seen in the estuaries of the tidal sloughs. Great blue herons, both the snowy and the common (American) egrets, black-crowned night herons, and American bitterns, are the usual wading birds. Cormorants, western and eared grebes, coots, and several species of terns and gulls, will usually be fishing in the shallows. Occasionally brown pelicans soar over, although they are more apt to be found on the salt ponds or fishing in the open Bay. Ruddy ducks and locally resident puddle ducks spend much time in the estuary.

The open waters of the South Bay are a favored rafting location for the many thousands of diving ducks that winter in San Francisco Bay. All of the Bay's diving duck species--lesser and greater scaup, canvasback, redhead, scoter, bufflehead--will be found here, but the open waters of the South Bay appear to attract more of the scaup than any other diving duck species. Most of the canvasback, for example, are usually rafted in San Pablo Bay, the scoters and many scaup in mid-Bay, and the bufflehead concentrate near the Richmond mud flats or Richardson Bay. Rafts of puddle ducks, such as pintail and mallard, may show up anywhere in the Bay, but they are more usual in North Bay or off Newark than in the Santa Clara Baylands.

One platform blind is found in the open waters off Guadalupe Slough estuary. This is the only blind noted in the vicinity--a contrast to the shallows off Palo Alto, Redwood City, or Burlingame where several score such blinds are located. The waves and winds may make building a blind or hunting here too risky, or it may be the flight patterns of the area are not conducive to hunting success. This last factor is probably the decisive one, for no avid duck hunter ever really counts the risk or discomfort if ducks are flying within range. This is borne out by statistical evidence from Fish and Game waterfowl records:

> "Using fall and winter census data for the years 1964 through 1966, for various sectors of the San Francisco Bay complex in relation to the acres of marshlands available . . . in the San Pablo region during January the average number of puddle ducks per acre was 1.0. Marshes in the mid-Bay region averaged 1.3 puddle ducks per acres, while the South Bay averaged 0.40 ducks per acre. The Suisun Marsh averaged 5.0 puddle ducks per acre for the same period . . . ."

These data on puddle ducks in the South Bay probably reflect a similar pattern for diving ducks.

Although the South Bay waters can claim no comparative pre-eminence in waterfowling or fishing, the opinion of biologists who have studied the South Bay is nearly unanimous in lauding the outstanding potential of these shallow waters for commercial oyster, clam, or shrimp production--when and if the pollution in the South Bay is eradicated. Historically, this area used to support a thriving shellfish industry until contamination wiped it out. The South Bay shallows, particularly within the Baylands study area, can probably never support profitable sport fishery or pleasure-boating enterprises on a large scale.

B. COMPARATIVE EVALUATION SUMMARY

Comparing the Baylands to other marshlands in the San Francisco Bay complex, or elsewhere in California or the rest of the world is, in part, an exercise in futility. Whatever the evaluation, high or low, the fact remains this is the marshland we have here, the Baylands are what we must work with, this is the land we degrade and lose or upgrade and profit from.

The ecological inventory has described the biotic entities found in the study areas today. The historical perspective of Chapter III has outlined how these biotic entities reached this stage, starting from the prehistoric past. The Baylands marshes are incredibly complex; the preceding biological resume skims only a bit off the surface. But we do know enough from this to make initial evaluations, to compare with other entities, and to suggest courses of action in some instances.

A comparison has already been drawn concerning the waterfowl value of this area. Both in terms of hunter success and of productive waterfowl habitat, the Baylands rank below mid-Bay, both the east and west sides, below San Pablo and Napa marshes, and far below the unique Grizzly Island-Suisun Marsh area. The Suisun, of course, is one of the world's great waterfowl marshes, the largest contiguous marshland in all 49 states outside of Alaska, which has larger ones. Compared to waterfowl and waterfowling in places such as Tule Lake, Butte Basin, the Delta, or the Grasslands, the Baylands show up a poor last. Unfortunately, the Baylands have not improved over the years. Less and less foraging marsh is left; only the tidal sloughs and their sparse fringes of alkali bulrush remain to feed hungry pintail and mallard.

However, the shorebirds in the Baylands, thanks to the continued existence of the solar evaporation salt pond system, can stand comparison with any area in California, even Tule Lake and the Lower Klamath. It is probable that there are as many or more shorebirds here, acre for acre, and botulism does not reap its yearly toll in the Baylands.

Wading birds in the Baylands find forage niches, but there are no nesting colonies such as those found in mid-Bay sites. They could and should be developed.

The sports fishery and recreational boating has been catalogued. The Baylands rates the poorest in the Bay or Delta. Not much can be done to improve it. Even if Alviso Slough were dredged and concrete-lined, it would still silt in. If you take a boat out of the tidal channels into the open waters of the Bay, where are you? And what is there to see or do? You are hours of sailing away from safe boating or fishing waters, from islands or bridges, or white cities on hills and other boating scenery. The most dismal boat dock in the tightest backwater slough in the Delta has lists of eager patrons waiting to rent slip space, but there is no great lack of space in Alviso.

There is one outstanding environmental resource, however, that the Baylands possess in full measure, and one that is almost unique in the San Francisco Bay complex--a resource that is an unintentional by-product of the salt ponds. This resource is the sense of physical isolation that impresses everyone when he first crunches down a narrow salt-encrusted dike, stepping past strange crystalline vegetation, breathing alien, new smells, and listening only to the wind and the eery thin cries of stilts and avocets. To some it is strangely disturbing; for others it fills a long-sought need. This is one of the environmental resources that must not be casually overlooked and heedlessly lost in community planning. To lose this is to deal a truly irretrievable blow to the environment.

C. RECREATIONAL USES AND CONSTRAINTS

Recommendations for recreational development and use of the Baylands have been advanced by many groups, and each group has been firm in its stand for right action and the greatest public good. The sincerity of each group is generally not in question, but their goals differ. Sometimes they differ so widely that, apparently, each group sees a different environment: the analogy of the blind men describing an elephant by feel applies.

There have been recommendations for day-use parks, green belts, inviolate wildlife sanctuaries, hiking trails, bicycle paths, automobile parking lots and viewpoints, horseback trails, restaurants, shops, marinas, recreational boating, sport fishing enhancement, retirement homes, bait shops, and a few people even think that the salt company might like to go on making salt.

From an environmental viewpoint, only a few of these goals are unreachable if enough fresh water is diverted or purchased, enough public will expressed, and enough public money spent. The varied goals cannot all be attained simultaneously or immediately, but most can be attained if the public wants them.

However, there are ecological keystones that should not be further touched, either by encroachment or modification. Foremost among these untouchables are the Bayland tidal mudflats and tidal sloughs. Too much loss has already occurred. No matter how attractive the economic mirage or the engineering plans, the environmental stresses are so near the critical point that ecological imperatives must, in this case, prevail. Any additional impoundments of tidal flats, any further dredging of tidal slough channels, will irretrievably damage the ecosystem in which we all live. The climate we live in, the food we eat, and the air we breathe ultimately are based upon the primal productivity of the oozes and mucks.

It has been suggested that, should the public obtain possession or control of the salt ponds and should there be no further need for salt, the outboard levees of the ponds could be broken open for tidal action and a pristine tidal marsh would reappear. This just would not happen. The pond levels have subsided, the soil salts have reached high concentrations. What would probably result would be a morass of sterile muck--unproductive, noisome, dangerous and impassable. A salt pond can be gradually turned into a managed marsh with water control gates, pumps, levee repairs, and a circulating pond system with fixed water levels. However, it will require knowledgeable planning and much money. This should be the procedure for the National Wildlife Refuge to follow.

The question of recreational access is broached. If the productivity of the Baylands wildlife is to be enhanced or even maintained at its present levels, access for the general public must be supervised, limited, and directed. Wildlife can literally be watched to death; even occasional disturbance will cause brooding birds to desert their nests or nursing mammals to destroy their young. Furthermore, the experiences of any local park director will point up the hazards of senseless vandalism and callous littering that plague public recreation areas. Access to recreation sites must be planned and scheduled, with consideration for wildlife as well as human use. Access must be segregated: automobile access from foot traffic; horse from bicycle; and motorcycle from everything. Adequate wildlife demonstration and exhibit areas may be possible, but some wildlife sites will probably have to be inviolate sanctuaries.

Terminated sanitary fills have been suggested for city park sites; the City of Mountain View is implementing such a plan. From the environmental view, a program that converts an unsightly raw fill into a green hill is admirable. But the landscape planning and even some of the landscaping should be undertaken before the fill is fully structured; it may be possible to build in enhancement features earlier and thus cheaper.

Adding vertical elements to the landscape--that means planting a lot of trees and shrubs--is desirable. The benefits added to salt pond wildlife by the power lines have already been described. Wherever possible, on the upper perimeters of the Baylands, trees or tall shrubs should be planted. Adequate landscaping, however, requires adequate fresh water, most feasibly provided by domestic water out of pipes. The financial burden will not be light.

In any comprehensive community plan, the remnants of the riparian habitats along Coyote Creek and Guadalupe River should be included. Any further intensive modification of the waterways should not be made until a detailed ecological and recreational analysis is made. At present some opportunities still remain for a meaningful restoration of these beleaguered streams to an urban stream-side green belt. These options will no longer exist if further urban development is free to continue the piecemeal dismemberment of the streams.

CHAPTER VIII

GEOLOGY, SOILS, AND SEISMICITY

In a consideration and evaluation of alternative use and development policies, a knowledge and understanding of the underlying geologic and soil structure of the Baylands and of the relative vulnerability of the area to earthquakes is as important as the consideration of surface characteristics of the area. This chapter discusses and describes these less obvious but highly important aspects of the study area.

Portions of the Baylands have been the subject of numerous geologic and engineering reports prepared by various public agencies and private entities. Geologic reports on the area have been published by the California Division of Mines and Geology and the United States Geologic Survey. In addition, other reports on geologic and engineering investigations have been made for specific projects and sites. For the purpose of this study, considerable use was made of these reports, especially the geologic information developed for the study area entitled *Geology and Structural Engineering* prepared in 1970 for the Baylands Subcommittee of the Planning Policy Committee of Santa Clara County by Woodward-Clyde & Associates, Consulting Soil Engineers and Geologists, and Frank E. McClure, Consulting Structural Engineer.

No soil exploration or testing was performed for this study. Logs of existing test borings and water wells which were available from various sources were cataloged and studied to provide information concerning the subsurface soil conditions at various locations in the study area. Over 640 boring logs were cataloged for this study and are presented in a separate volume filed with the Santa Clara County Flood Control and Water District. The logs are indexed for location by reference to a map of the study area which is included in the catalog.

A. GEOLOGIC AND SOIL CONDITIONS

The Baylands of Santa Clara County comprise the sloughs, marshes and lowlands at the northerly end of the Santa Clara Valley and the southerly end of San Francisco Bay. Topographically the Santa Clara Valley and San Francisco Bay are two parts of a wide northwesterly trending valley lying between approximately parallel mountain ridges of the Central Coast Range. The submerged portion of the valley, San Francisco Bay, is generally shallow, having water depths averaging less than 10 feet in the study area.

In the mountain ranges on both sides of the valley are well defined, active earthquake fault zones. Numerous splinter faults have been mapped and inferred from geologic and geophysical studies. The San Andreas fault zone to the west and the Hayward and Calaveras fault zones to the east are the principal active fault systems in the region and are capable of producing large destructive earthquakes.

1. Alluvium and Bay Mud

The Baylands area is underlain by deep deposits of alluvial sediments. The bottom of the Bay consists of soft deposits of silty clay, known as Bay Mud. The alluvium is exposed over most of the southern portion of the Baylands. Bay Mud overlies the alluvium in the area occupied by salt ponds and marshland. The Bay Mud ranges from a thickness of a few feet at the southern shoreline of San Francisco Bay to about 30 feet along the submerged channel of Coyote Creek. (See Plate 9.) The Bay Mud was deposited upon a topographically irregular erosion surface and is therefore of variable thickness. Embayments of mud and soft clay, hidden beneath a cover of recent alluvium, exist farther south along abandoned stream channels near the Guadalupe River and Coyote Creek.

The alluvium was deposited by the many streams emptying into the San Francisco Bay depression from the surrounding hills. Near stream channels sand and gravel were deposited. At greater distances from these channels overflow deposits of silt and clay were deposited. From time to time the streams changed course and deposited sand and gravel lenses at slightly different locations. As a result of varying deposition and erosion, the alluvium gradually built up as a series of lenticular layers of sinuous sand and gravel deposits which were separated and encased within extensive layers of silt and clay.

The stream depositional environment was complicated, as it is today, by the presence of ancestral San Francisco Bay. Extensive blue clay layers are reported in water well logs, which were probably laid down as ancient Bay Mud deposits. During periods of continental glaciation, when vast quantities of ocean water were trapped as glacial ice, sea level was as much as 350 to 400 feet lower than it is today and the valley that is now San Francisco Bay was exposed in many areas. During these periods vast quantities of streamborne sand and gravel were deposited.

2. Bedrock Features

The bedrock floor lies at depths ranging from 600 to 2,400 feet beneath the Baylands. Contours of equal bedrock surface elevation based on gravity survey data are shown on Plate 10. The bedrock surface shows several linear features which have been interpreted as faults, but there is no evidence to suggest that the northern extension of the Silver Creek fault or other possible faults in the bedrock are presently active.

These possible fault features are roughly parallel to both the San Andreas and Hayward fault systems and lie between them. In the event of a future large earthquake on the San Andreas or Hayward faults, there is the possibility that sympathetic movement might occur on such subparallel faults lying beneath the Baylands. Such sympathetic movements have been known to occur on active faults during large earthquakes on other faults. While movement on these buried faults remains a possibility, so little information exists concerning them that they have not been considered as a factor in establishing earthquake risk zones in the Baylands.

3. Soils

The upper soils in the Baylands consist of lenticular alluvial deposits of sands and gravels, silts and clays. The sand and gravel deposits generally vary in density from loose to medium. In most areas where information is available on the boring logs, the density of the shallow deposits of sands and silts varies from very loose to loose, based on the standard penetration blow counts recorded on the boring logs. The clays vary from very soft Bay Mud deposits to very stiff clays.

Applied loads of structures or fills would subject the soft clay soils and loose sand and silt deposits to localized settlement. Localized settlement occurs primarily because of densification of the shallow soils under applied loads. The areal extent of localized settlement usually is confined to the immediate vicinity of the structure or loading. Localized settlement is characterized by differential settlements between areas depending on the applied loads, the compressibility of the soils, and the depth of the compressible soils.

4. Subsidence

Subsidence is characterized by a reduction in the ground surface elevation over large areas. The study area, as part of the Santa Clara Valley, has undergone varying amounts of subsidence since records were first established in 1912. (See Plate 11.) The subsidence experienced in Santa Clara Valley is due to the withdrawal of groundwater from deep aquifers and has resulted in consolidation of the clay layers adjacent to these aquifers as the groundwater level was lowered by pumping from wells. Areal subsidence has been in progress essentially as long as groundwater has been pumped from the deeper wells for use in the valley. The rate of areal subsidence has been substantially reduced in recent years due to the importation of water from outside Santa Clara Valley and the substitution of this water for water which was formerly pumped from wells. Local runoff water and imported water are also used in a program of recharging the groundwater aquifers to maintain the groundwater levels at or above their present elevation. This has had the intended effect of reducing the rate of subsidence.

Future areal subsidence of the Baylands could occur due to additional groundwater pumping or redistribution of the existing groundwater pressures. It is estimated that a maximum future subsidence of about 4.5 feet might occur within the next 350 years, if no significant additional lowering of the groundwater table is experienced. Approximately 50 percent of this subsidence would occur within the next 75 years.

The effects on the levees of areal subsidence and of settlement are similar in that each results in a lowering of the crest of the levee. However, the effects of localized differential settlement and the effects of long-term subsidence result from different causes which should be dealt with individually.

5. Typical Subsurface Profiles

An analysis of 148 water well and 478 boring logs in the Baylands shows that the subsurface geologic conditions to a depth of 100 feet can be divided into five idealized soil profiles. These profiles provide a means of describing the expected behavior of the ground surface resulting from static and seismic loading. For this study the uppermost 100 feet of the alluvium are of primary interest because the behavior of the land surface due to static loading (structures and fills) and seismic loading (earthquake shaking) is strongly dependent on the nature of the sediments to that depth.

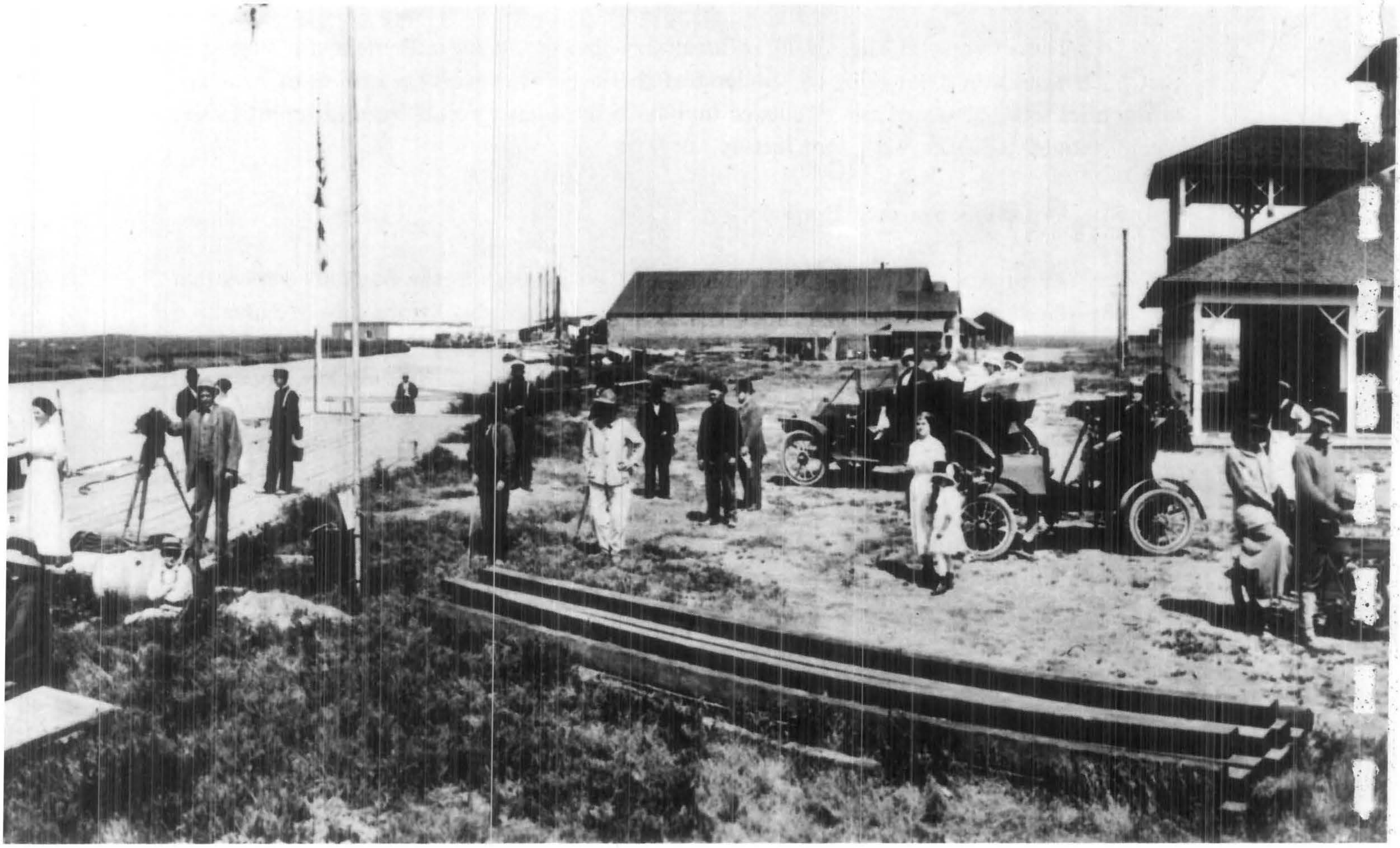
The soil profiles are numbered from I to V in order of increasing susceptibility to foundation and stability problems resulting from static and seismic loading. All of the five profiles may be overlain by refuse or fill placed by man. Such surface material will modify the behavior of the land surface as compared to its natural state when subjected to static and seismic loading. These soil profiles are described below and are shown graphically in Plate 12.

Profile I represents a condition in the alluvium in which the upper 100 feet are composed of stiff clay. Alluvium of this composition is relatively common between the main stream courses where a fine-grained depositional environment has predominated for long periods.

Profile II is a condition within the alluvium in which the stiff clay contains a layer of sand and gravel at a depth of about 70 feet. While this depth is most common, some well logs show sand and gravel layers at shallower depths ranging up to within only a few feet of ground surface.

Profile III is within the alluvium and is similar to Profile II with the addition of a sand and gravel layer near the ground surface overlain by a thin layer of firm clay. This section is typical of areas near recent stream courses and the near-surface sand and gravel layer represents a very recent stream deposit.

Profile IV is the same as Profile II with the addition of a section of sand overlying



South Bay Yacht Club, Alviso, 1914

either Bay Mud or soft clay. This condition is typical of the region near the Bay between these two streams. The surface sand layer represents a very recent stream deposit.

Profile V is typical of all portions of the Baylands where salt ponds and marshlands exist. These areas are underlain by Bay Mud. Profile V shows Profile II conditions with the addition of a layer of Bay Mud just beneath ground surface. The mud thickness ranges from a few feet to the maximum observed in borings of 30 feet.

In each of the five profiles, the position of the sand and gravel layer may be anywhere within the section of stiff clay; however, such layers are most commonly described on well logs at depths greater than about 70 feet.

6. Use of the Profiles in Establishing Geologic Risk Zones

Two principal ground surface effects may be expected due to static and seismic loading:

a. Settlement, including differential settlement as distinguished from areal subsidence.

b. Failure of the ground surface.

These two surface effects can be caused by five separate mechanisms including:

a. Liquefaction of confined saturated granular layers during earthquake shaking;

b. Consolidation of Bay Mud or soft clay under static loading;

c. Consolidation of uncontrolled dumped fill such as sanitary land fill under static loading;

d. Liquefaction of surficial granular layers under earthquake shaking; and

e. Lateral spreading toward a free face under earthquake shaking.

Lateral spreading, as used in this report, is a mass movement of the land in a generally horizontal direction in response to seismic ground motion. Such movement will only occur toward a lower topographic position, referred to as a free face. Such free faces are provided by shorelines, drainage ditches, stream gullies, ship channels and sloughs.

South Bay Yacht Club, Alviso, 1972

Subsidence of the ground surface elevation of the Baylands, due to groundwater withdrawal, has occurred in varying amounts since records were first established in 1912. Alviso, which subsided six feet between 1934 and 1967, is now at an elevation of 2.0 feet below mean sea level.

7. Geologic Risk Zones

The expected behavior of the ground surface, resulting from static and seismic loading of the subsurface materials, can be related to the five subsurface profiles. Table 12 shows the surface effect and its subsurface cause and identifies these conditions in terms of four geologic risk zones, A, B, C, and D.

Plate 12 shows the geologic risk zone to which each water well or test boring log is assigned on the basis of the information contained on the log. The individual well or boring risk zone values shown on Plate 13 were used, together with knowledge of the areal geology, to establish the geologic risk zones shown on Plate 14. The wells and borings used for control of risk zone boundaries are included to show the relative reliability of these boundaries.

Despite the large number of logs for control in some areas, the geologic risk zones shown on Plate 14 still provide only a general guide to the subsurface conditions that exist in the Baylands. For example, within any area assigned a specific risk zone classification, there may be smaller areas, where no logs are present, that have either better or poorer risk potential. For any given site, a final determination of the subsurface conditions and the consequent risk zone classification, will depend on the findings of a specific subsurface exploration of the site. Changes in the risk zone boundaries and classifications on Plate 14 may be expected as additional subsurface information becomes available and is incorporated into the geologic risk zone system, just as the risk zones shown on Plate 14 represent a refinement of the risk zone map developed in 1970 for the Baylands Subcommittee of the Planning Policy Committee.

The four geologic risk zone classifications are described as follows:

a. Risk Zone A includes those areas of the Baylands in which the surface effects resulting from static and seismic loading will be insignificant.

b. Risk Zone B includes those areas where significant settlement may occur as a result of liquefaction of deeply buried granular layers in the alluvium.

c. Risk Zone C includes those areas where moderate to substantial settlement and/or differential settlement may occur as a result of consolidation of Bay Mud. Bay Mud is not considered to be capable of liquefaction during seismic loading.

d. Risk Zone D includes those areas where substantial settlement and/or differential settlement and ground failure may occur. Settlement may occur as the result of consolidation of uncontrolled dump fill or sanitary land fill which behave more erratically than Bay Mud. Ground failure may occur under seismic loading as a result

TABLE 12

GEOLOGIC RISK ZONES ESTABLISHED BY SUBSURFACE CONDITIONS IN THE BAYLANDS OF SANTA CLARA COUNTY

SURFACE EFFECT	SUBSURFACE CAUSE	PROFILE	RISK ZONE A	B	C	D
1. Significant Settlement	Liquefaction of Confined Granular Layer in Alluvium (Seismic Loading)	II_e*		X		
2. Moderate to Substantial Settlement and/or Differential Settlement	Consolidation of Bay Mud or Soft Clay (Static Loading)	IV_d* V_d			X	
3. Substantial Settlement and/or Differential Settlement	Consolidation of Uncontrolled Dump Fill or Sanitary Land Fill (Static Loading)	Not Shown				X
4. Failure of Ground Surface	Liquefaction of Granular Surface Layer (Seismic Loading)	III_e IV_e				X
5. Failure of Ground Surface	Lateral Spreading Toward Free Face (Seismic Loading)	III IV V				X

* d — dense granular layer present; e — loose granular layer present

of lateral spreading toward a free face or by liqeufaction of near-surface granular layers. Conditions for both lateral spreading and liquefaction are present in portions of the Baylands.

8. Lateral Spreading

Lateral spreading induced by earthquake shaking may occur if there is an area at a lower elevation into which soft soils can move. The phenomenon of lateral spreading is most common in areas adjacent to excavations or free faces provided by canals, drainage ditches, shorelines, and ship channels.

Much of the damage in San Francisco during the 1868 and 1906 earthquakes was caused by lateral spreading. Lateral spreading under earthquake shaking is one of the better documented effects produced in the Baylands during the 1906 earthquake. The following accounts recorded in 1908 in the *Report of the California Earthquake Commission* on the 1906 earthquake illustrate the need for concern. It will be noted in these examples that all were observed near residences or public roads, which suggest that such effects probably occurred elsewhere in the Baylands but were not observed because of the low population density in the area and the lack of easy access to the marshlands.

> "In the road running northward along the west side of Coyote Creek from the bridge, many large cracks opened. Five hundred feet north of the bridge the cracks were 2.5 feet wide and 3 feet deep when the place was visited April 26. Farther north the cracks were very abundant, mostly parallel with the road, and some were 4 feet deep and 3 feet wide. A quarter of a mile north of the bridge, the whole road was shoved eastward into the channel of the creek, and with it a large number of willows and cottonwood trees that grew along the banks. Just south of this place the road was broken up badly for a distance of 300 feet. One of the largest cracks in the road was 5 feet wide, 6 feet deep, and more than 100 feet in length. The bearing of the fissures at this place was N. 23° W. For the most part the principal features were approximately parallel with Coyote Creek.
>
> " Cracks like those which were observed in the ground on the Milpitas-Alviso Road reappeared on both sides of the Coyote River at intervals all the way to San Jose. Although they occur in a general north-south direction, it seems probable that their origin was due to the unstable condition of the alluvial deposits which underlie the valley."

9. Liquefaction

Liquefaction is the second mechanism by which ground failure can occur. Profiles III and IV, in which sand or sand and gravel are located at or very near ground surface, provide the condition in which liquefaction can cause ground failure.

Test borings in the Baylands suggest that loose sands do occur sufficiently close to the ground surface to provide the potential for liquefaction during earthquake shaking. Areas where loose sands occur are located generally along existing stream courses, primarily near the Guadalupe River and Coyote Creek, and represent very recent unconsolidated stream deposits. In several borings, the loose sands were overlain by very firm to stiff silty clay. Therefore, the presence of relatively stiff clay is no assurance that loose sands will not exist at great depths.

The position of the water table is a very important consideration in evaluating liquefaction potential, since it cannot occur except under saturated conditions. Test hole logs indicate that the water table is within 12 feet of the surface throughout the Baylands. In the northern portion of the Baylands, where the marshlands and salt ponds are located, the water table is only a few feet below ground surface. Therefore, the saturated conditions necessary for liquefaction are present nearly everywhere in the Baylands.

The following quotation from the *Report of the California Commission* provides evidence that liquefaction and ground failure did take place during the 1906 earthquake in portions of the Baylands.

> "From 1,500 to 2,000 feet west of the bridge over Coyote Creek, cracks cross the road in front of the Boot ranchhouse, and several of them occur in the road leading to that house. Some of these cracks are about 6 inches wide and have a general bearing of N. 43° W. Immediately after the earthquake, water flowed from sone of them and brought up sand, which was heaped up about 6 inches high. The water ceased to flow after the second day.
>
> "At the bridge over the Coyote Creek, on the Alviso- Milpitas Road, the concrete abutments were thrust inward toward each other about 3 feet. A pile driven in the middle of the stream, which had been cut off below the water-level, was lifted about 2 feet and now rises above the water.
>
> "West of the stream, in an adjoining field, water rising through cracks built up many craterlets of sand. Residents of the vicinity state that the water rose 3 or 4 inches above the tops of these craterlets

> while they were being formed, and that it ceased to flow toward the end of the second day after the earthquake.
>
> "At Mrs. North Whitcomb's ranch, on the south side of the Alviso-Milpitas Road, between Coyote Creek and Milpitas, the prune orchard was cracked and the ground shifted at several places. The ranchhouse, of concrete, with a wooden upper story, was cracked across the northwest corner and settled slightly on the northwest side. In the backyard were fissures 1-foot wide, running about N. 13°W. with a downthrow of 1 foot on the east side. Some of the prune trees in the orchard are 2 feet out of alinement, and some as much as 6 feet. The lateral displacement here shows a relative movement of the south side toward the east. Considerable sand was brought up by water flowing from the cracks in this orchard."

The clues that the observed effects were most likely the result of liquefaction are provided by the escape to the surface of water and sand, the inward movement of the Coyote Creek bridge abutments and the rising of a wood pile in the stream channel, and the cracking and shifting of the land surface in the orchard.

B. SEISMICITY

The seismicity evaluation made during the course of this study is intended only to serve as a guide in estimating the magnitudes, recurrence intervals, and locations of future earthquakes that potentially will be damaging within the study area.

Steps were taken to review and evaluate the regional seismicity of the San Francisco Bay Area, to estimate the magnitude of earthquakes that are likely to occur as a result of future activity, and to estimate the probability of surface faulting along the nearby faults. This evaluation considered the distribution of historic earthquakes, the overall length of the faults, the length and type of faulting that has occurred in the past, and geomorphical evidence of fault activity.

Based on the results of this evaluation, estimates were made of the magnitudes of earthquakes that appear capable of occurring along the major active faults in the vicinity of the Baylands study area under the presently known geologic framework, of the magnitudes of the "maximum probable" and the "maximum credible" earthquakes that are most likely to occur on each fault, and of the corresponding estimated range of recurrence intervals in years between these events. The results of this preliminary seismicity evaluation are presented in Table 13.

TABLE 13

POSSIBLE DESIGN EARTHQUAKES

FAULT SYSTEM	EARTHQUAKE MAGNITUDE	ESTIMATED RANGE RECURRENCE INTERVAL BETWEEN EVENTS IN YEARS	LIKELIHOOD FAULT BREAK WILL OCCUR ON SEGMENT CLOSEST TO SITE	RELIABILITY OF DATA
San Andreas	8.5*	500 to 1000	100%	GOOD
	8	100 to 500	100%	
	7.5	60 to 150	100%	
	7	50 to 100	90%	
	6.5	25 to 50	75%	
	6	10 to 30	50%	
	5.5	5 to 10	40%	
	5	2 to 5	30%	
Hayward	7.5*	500 to 1000	100%	GOOD
	7	100 to 500	100%	
	6.5	50 to 100	90%	
	6	25 to 50	80%	
	5.5	10 to 20	50%	
	5	5 to 10	30%	
Calaveras	7.5*	500 to 1000	100%	FAIR
	7	100 to 500	100%	
	6.5	50 to 100	90%	
	6	25 to 50	80%	
	5.5	10 to 20	50%	
	5	5 to 10	30%	

* Maximum Credible

This seismicity evaluation of the San Francisco Bay Area is based on:

1. A review of all earthquakes listed by the University of California at Berkeley as occurring in the San Francisco Bay Area between 1800 and 1968.

2. A tabulation of all earthquakes between the years 1942 and 1968 in the San Francisco Bay Area, as recorded by the University of California at Berkeley. A total of over 2200 individual earthquakes was recorded.

3. Statistical analyses of the 1942-to-1968 earthquakes by the method of recurrence curves. (Gutenberg and Richter, 1954; Allen, et al, 1965; and Ryall, et al, 1966; see Bibliography in Appendix A.)

4. Review of existing recurrence curves (Ryall, et al 1966), and recurrence intervals (Wallace 1970) of the San Francisco Bay Area.

5. A brief review of the historic displacement and length of surface fault rupture along the active faults.

6. A brief review of available geological publications to estimate the geomorphic evidence which indicates the length of the active segments of the fault trace.

7. Incorporation of our previous field observations and experience in this type of evaluation.

1. Historic Activity

In order to evaluate the degree of seismic activity that might be experienced in the future, the full earthquake record of the San Francisco Bay Area has been analyzed, for it has been reasonably well established that earthquakes will most likely recur in the same general area where they have occurred in the past.

There are three known major earthquake faults within the San Francisco Bay Area capable of producing strong earthquakes. The location of these faults in relation to the Baylands study area is illustrated in Plate 15. These faults are the San Andreas Fault, which is approximately seven miles west of the study area at the nearest location; the Hayward Fault System, which is located approximately one mile east of the area; and the Calaveras Fault System, which is located about five miles east of the area. The minimum, maximum and average distances from the Baylands to the faults are shown on Plate 16.

Strong earthquakes accompanied by surface faulting occurred in the San

Francisco Bay Area in 1836, 1838, 1861, 1865, 1868, and 1906. The locations of the surface faulting are shown on Plate 15. The earthquakes and others of lower magnitude have caused considerable destruction at frequent intervals throughout historic time. Some of the stronger events are listed in Table 14.

The maximum lengths of historic surface rupture have been 270 miles on the San Andreas fault, 30 miles on the Hayward fault, and an unknown length along the Calaveras fault. The magnitude of an earthquake, as originally defined by C. F. Richter, is the rating of the earthquake relative to the earthquake energy released at the source. The Richter magnitude is expressed in whole numbers and decimals and in a logarithmic scale. The maximum Richter magnitude of earthquakes related to these events was 8.25 on the San Andreas fault. The magnitudes along the Hayward fault in the large earthquakes of 1836 and 1868 and the Calaveras fault in 1861 earthquake are unknown. Intensity is a rating of the severity of ground motion at a specific location. It is commonly measured on the modified Mercalli Intensity Scale, with a maximum of XII. Intensities of IX and X were reported along both the Hayward and Calaveras faults during these earthquakes and indicate that the magnitudes were probably about 7.

Two concealed fault traces have been mapped as projecting through or close to the subject site. These traces are associated with the Silver Creek fault zone. Available evidence indicates that the fault zone does exist southeast of San Jose and probably exists within the bedrock which is found at least several hundred feet under the site.

Active fault traces produce subsurface features which include ground water barriers, a higher water table on one side of the fault in relation to the other side, and displacement of water bearing layers. None of these features have been found along the reported Silver Creek fault zone north of the study area in the vicinity of Newark, California.

If the Silver Creek fault zone is present within the bedrock beneath the study area, it does not appear to have displaced the upper sedimentary deposits. This indicates that the fault zone is considerably less active than the Hayward fault, that the period of recurrence of fault movement is extremely long, and that primary surface faulting is unlikely at this site.

2. Maximum Probable and Maximum Credible Earthquakes

The maximum probable earthquake is the maximum earthquake that, on a statistical basis, will most likely occur during a certain interval of time. However, it is regarded only as the most probable occurrence, not an assured occurrence at any specific time.

TABLE 14

STRONG EARTHQUAKES REPORTED IN THE SAN FRANCISCO BAY AREA AND INFLUENCING THE BAYLANDS STUDY AREA

Date	Richter Magnitude
1836	7*
1838	7*
1868	6.75
1906	8.25
1911	6.50
1943	5.50
1945	4.50
1947	4.50
1949	4.50
1954	5.50
1955	5.75*
1955	5.50
1957	5.50
1958	4
1959	5.3
1963	5.4
1964	5.1
1969	5.6

* Estimated Magnitude

The maximum credible earthquake is the maximum earthquake that appears capable of occurrring under the conditions of the presently known geologic framework. It is a rational and believable event even though its interval of recurrence may be long. In determining the maximum credible earthquake, there is little regard to its probability of occurrence, except that its likelihood of occurring is great enough to be of concern. The recurrence method is a statistical analysis of seismological and geological data for events that have occurred, and is reliable to the extent that it is assumed past events reflect what may happen in the future.

The study of geological and geomorphological evidence indicates that the maximum credible magnitude earthquake for the San Andreas is 8.5, for the Hayward 7.5, and for the Calaveras 7.5.

The maximum probable and maximum credible earthquakes are large and they produce destructive effects. These effects are likely to be manifested in one or more of the following ways:

a. Surface faulting along the active fault zones;

b. Ground failure associated with liquefaction, slope instability and settlement;

c. Structural failure caused by intensive ground motions;

d. Waves generated in the Bay as a result of the motion.

3. Proximity of Surface Faulting

Surface faulting will probably occur along existing faults where the geological evidence shows that past movements have repeatedly occurred. Therefore, the faulting would be limited to a fairly narrow zone parallel to the active fault traces. Associated with the primary faulting along the main fault is splinter or secondary faulting. This faulting forms at a low angle to the main fault and ruptures out into the surrounding countryside for several hundred to several thousand feet, but rarely several miles. These splinter or secondary faults are not common; they occur at widely spaced, random, unpredictable locations along zones of surface faulting and, therefore, represent a fairly low risk to sites located several thousand feet away from the zone of surface rupture. Surface faulting associated with displacement along the recognized faults is not considered likely within the study area.

At their closest points the San Andreas fault is located about seven miles west of the study area and the Hayward and Calaveras faults are located one and five miles east of the study area, respectively. The probability is high that surface fault rupture will occur along a segment of the San Andreas, Hayward, and Calaveras faults closest to the Baylands, based on historic activity, geomorphic evidence strongly suggesting recent activity, the location of earthquake epicenters, the history of repeated faulting in the same area, and the geological framework.

4. Earthquake Recurrence

The recurrence interval for earthquakes along each of the three major faults may be of greater importance than the proximity of the Baylands to surface faulting, or to the epicenters associated with earthquakes. As shown in Table 13, the estimated recurrence interval for earthquakes of a given magnitude on the San Andreas fault is generally about one-half the recurrence interval for the same magnitude earthquakes on the Hayward and the Calaveras faults. This suggests that the San Andreas fault is twice as active as the Hayward and the Calaveras faults.

5. Earthquake Effects

a. Ground Motions.

The ground motions that could be generated by an earthquake in the Baylands depend on the local soil conditions and on the magnitude and distance of the earthquake.

At this time, it is not possible to establish levels of ground motions in the Baylands for all possible earthquakes and for each of the representative soil conditions. To do so would require a very detailed study, beyond the scope of this investigation. However, ground surface accelerations greater than 0.4g (0.4 times acceleration gravity, which is 32.2 feet per second per second) could be generated in the study area during a very strong earthquake on the Hayward or San Andreas faults. The estimated ranges of ground surface acceleration due to earthquakes of various magnitudes and distances from the study area are presented graphically in Plate 17.

b. Liquefaction Potential.

The liquefaction potential depends on the presence of liquefiable material, the subsurface water level, and the magnitude and distance of the earthquake. Profile I soil types (see Plate 12) appear to have no potential for liquefaction. Profiles II, III, IV and V have varying degrees of liquefaction potential, depending on the intensity and duration of ground motion. With a ground water level assumed to be at 5 feet below ground surface, liquefaction of loose granular soils in Profiles II to V is estimated to be possible when the ground surface acceleration is greater than 0.15g to 0.20 g.

c. Levee Stability.

Slope instability during earthquakes may be attributed to failure of soils within the slope or the soils underlying the slope. Field observations have indicated that conditions leading to slope instability could be categorized as follows:

1) Flow slides caused by liquefaction of cohesionless soils usually involving sands, gravelly sands with sand seams, silty sands or loess.

2) Slides caused by liquefaction of thin seams or lenses of sands within a matrix of cohesive soils.

3) Slides in cohesive soils, probably due to high inertia forces.

4) Slumping of fills on firm foundation soils, probably due in part to compaction and in part to high inertia forces.

5) Slumping and collapse of fills due to liquefaction or failure of loose saturated silt and sand foundation soils.

It has been assumed that new levees will be constructed of soils with a very low susceptibility to liquefaction. Therefore, the type of instability indicated in 1) above is unlikely to occur within new levee embankments. Conditions leading to type 2) above may be presented in the Baylands along natural or dredged channels. The most likely conditions leading to instability of the levees would be found in types 3, 4 and 5 identified above. Types 3 and 4 are likely to be associated with Profile I and maybe with Profile II if the accelerations and duration are not high enough to cause liquefaction in the deep sandy layer. The inertia force will be a function of the earthquake under consideration and could be greater than 0.4 g. The stability of levees in areas where the underlying soil conditions are represented by Profiles III, IV or V would be controlled by the liquefaction of the underlying sandy layers.

C. SUMMARY

From the brief citation above, it can be seen that the particular geologic characteristics of the Baylands present foundation and structural engineering problems to development that are generally absent elsewhere in Santa Clara County. Much of the area--all of the salt ponds and a fringe of dry land including part of the community of Alviso--are below sea level and are susceptible to salt water flooding. Present protection is provided by levees constructed primarily to contain the salt ponds used in the solar extraction of salt. The Baylands are located in one of the most seismically active areas in the United States. Although the study area is relatively free from the hazards of surface faulting, the stability of existing levees during a strong earthquake is questionable. The subsurface conditions in much of the Baylands study area, classified into four categories of geologic risk zones, pose the threat of liquefaction or lateral spreading during ground motion. The hazard to life and property varies under each geologic risk zone condition. These factors should be determined and analyzed in detail in the evaluation of specific development proposals.

CHAPTER IX

ALTERNATIVE PLANS AND DESIGN CRITERIA

For purposes of comparative analysis, alternative levee systems and location plans were considered and design criteria were developed for each. The alternative systems would provide a varying degree of protection from salt water flooding and fresh water flooding to portions of the Baylands, as described in this chapter.

A. Description of Alternate Plans

Each of the alternate protective systems entails a series of levees utilizing, for the most part, the alignments of existing levees; drainage systems and pumping stations to dispose of internal storm waters; and access roads on the levee structures designed to accommodate maintenance vehicles and equipment.

1. The "Do-Nothing" Plan

As the name implies, this alternative assumes that nothing will be done to alter or improve the system of levees which now exists and that the problems and hazards of salt water flooding, fresh water inundation, and occasional overtopping and erosion of existing levees would continue. The location of the existing levees and the agencies responsible for them are shown on Plate 18.

The existing levees were constructed primarily to enclose the salt ponds, and contain nearly 15,900 acres within the study area. The basic portion of this system, the series of "inboard" levees, provides a degree of protection to nearly 7600 acres of land, some of which are developed. This segment of the system extends from San Francisquito Creek on the west to Coyote Creek in the eastern sector of the study area. The outboard portion of the system extends along the shoreline at the edge of the former marshlands. Between the two major segments a series of levees contains each of the salt ponds and the major freshwater outfall channels and tidal sloughs. The present levees are owned and maintained by several private and public owners and agencies.

a. Appraisal of Existing Levees

The existing levees are of mixed earthwork construction. Bay Mud constitutes the basic construction material, but in some instances along readily accessible alignments of the inboard segment, imported fill materials have been used. No detailed stability analyses were made of these existing levees due to the wide variation in materials, types, and cross-sections. Almost without exception, the crest elevation is below that considered to be the minimum elevation which conforms with criteria used in this study and described in Section B below. The higher levees are found mostly along the major outfall channels, the outer edge of the salt ponds, and along major industrial sites or sewage treatment plants on the inboard segment.

Most of the existing crest widths are less than the 30-foot minimum width required by the District. They are sufficient to accommodate vehicles,but turning movements are limited along most of the alignments. The side slopes are at a maximum angle of repose--steeper than the 6 to 1 slope standard used in this study--and have no slope protection other than the natural vegetation described in Chapter VII. In most locations the existing levees are inadequate to provide dependable protection against salt water flooding of the Baylands under the conditions evisioned in this study.

b. Storm Drainage

Storm drainage systems presently existing within the study area are concentrated alongside or inboard of the existing inboard segment of the levees. Historically, the area occupied by the salt ponds consisted primarily of marshes with abundant vegetation. Sediment transported from the surrounding hills by streamflow and suspended salt water sediment brought by the tides entered the marshes and settled in the quiet water areas. Before the salt ponds were developed there existed direct drainage for storm water runoff into the Bay with a naturally defined tidal zone. When the marshlands were transformed into salt ponds by the construction of levees at the edges of the marsh, the storm water runoff was channelized around the ponds into the Bay.

Many large streams cross the Baylands and empty into the Bay. Levees have been built on each side of these streams to prevent some fresh and salt water flooding of the surrounding area, but they have not been built to a 100-year flood design standard. The drainage areas contributing to these streams vary from several square miles to several hundred square miles. The 100-year design flows presently in use by the District and those used in this study are as follows:

San Francisquito Creek at Highway 101	9,400 cfs
Matadero Creek at Highway 101	2,200 cfs
Adobe-Barron Creek at Highway 101	3,000 cfs
Permanente Creek at Highway 101	1,800 cfs
Stevens Creek at Highway 101	7,900 cfs
Calabazas Creek at Highway 101	3,550 cfs
San Tomas Aquino Creek at Highway 101	8,800 cfs
Guadalupe River at Highway 101	24,000 cfs
Coyote Creek at Highway 17	22,400 cfs

Essentially all developed lands within the study area require storm drainage systems which collect and discharge flows into major outfall channels or sloughs by means of pumping stations. All existing or programmed pumping stations are concentrated alongside or inside the existing inboard segment of the levees above the salt ponds. In most instances these systems include a small retention basin and a pumping station which contains one or more pumps. In recent years, individual Bayfront cities have developed and adopted master plans for improving their existing storm drainage systems. Today, many of those improvements are under construction or are in a final stage of being implemented.

In general, storm drainage systems and associated pumping facilities are owned, operated and maintained by the individual cities. However, the U. S. Naval Air Station at Moffett Field and the Lockheed Missiles and Space Company have constructed their own storm drainage systems to protect their areas during periods of severe storms. They presently operate and maintain their own systems.

Table 15 describes the location and capacity of major pumping facilities which presently exist or are programmed for construction within the study area. The location of these facilities is shown graphically on Plate 19.

2. Inboard Levee Plan

The proposed inboard levee plan alternative consists of a series of perimeter levees utilizing for the most part the existing alignment of the inboard levees extending from San Francisquito Creek in the west to Coyote Creek in the eastern portion of the study area. This alternative provides no protection for the salt ponds or other wetlands. This is the shortest of the alternatives considered, having a length of 180,400 lineal feet or 34 miles. The area to be protected from salt water flooding is estimated to be approximately 7,300 acres. The alignment adopted for the inboard levee alternative is shown on Plate 20.

The existing levees generally can be incorporated in the construction of future levee systems where the planned or proposed levee location would coincide with the existing levees. In the instance of the salt pond levees constructed of dredged Bay Mud, the levee sections envisioned for planning purposes in this report would be of similar construction, but they would be of more massive proportions. Preparation of the existing levees for additional filling and earthwork construction would consist primarily of the removal of vegetation and deleterious material from the levees in order to provide bonding of the new earthwork section with the existing section.

Some localized differential settlement between the new levee section and the existing levee sections may be experienced. This should be evaluated during detailed design studies in order that appropriate precautions and construction details may be incorporated

TABLE 15

LOCATION AND CAPACITY OF MAJOR DRAINAGE AREA PUMPING FACILITIES

FACILITY DESIG-NATION	LOCATION	OWNER	PLANT CAPACITY (CFS) EXISTING	PROGRAMMED
1	Palo Alto Airport	Palo Alto	15	60
2	Palo Alto Airport (East of existing plant)	Palo Alto	–	90
3	Colorado Avenue at Bayshore Freeway	Palo Alto	110	–
4	Matadero Creek at Stierlin Canal	Palo Alto	240	–
5	Adobe Creek at East Meadow Drive	Palo Alto	180	–
6	Coast Casey Industrial Park	Mountain View	12	–
7	Coast Casey Industrial Park	Mountain View	–	Unknown
8	Stevens Creek at Crittenden Lane	Mountain View	–	Unknown
9	Moffett Field	Department of the Navy	12	–
10	Lockheed Missiles and Space Company	Lockheed	90	–
11	Easterly of Sunnyvale Sewage Treatment Plant	Sunnyvale	80	133
12	Calabazas Creek (North of Route 237)	Sunnyvale	149	225
13	San Tomas Aquino Creek at Route 237 (Under construction – 36 acre-feet retention storage)	Santa Clara	89	–
14	Guadalupe River at Route 237 (Under construction – 35 acre-feet retention storage)	Santa Clara	134	–

to minimize the detrimental effects of such differential settlements. Because the materials used in the existing levees are similar to those recommended for use in the new levees, the material strengths of existing levees are similar to those of the proposed levees. However, the overall strength of the levees under the earthquake and hydraulic loadings are dependent on the geometry of the levee section, and, consequently, the existing levees are considered to be weaker than the levee sections proposed.

New local drainage facilities required under the Inboard Levee Plan are limited to the vicinity of Alviso. Drainage systems presently existing or programmed for construction in the immediate future are considered to be adequate for all other areas within the proposed alignment. For the Alviso area, five pumping stations with a combined capacity of 1,100 cubic feet per second are proposed to take care of the local drainage waters generated in this area.

3. Inboard Levee Plan with Channel Levees

This levee alternative is similar to the inboard plan previously described with the exception that protective levees are provided along all major outfall channels between Permanente Creek and Alviso Slough. The total length of this sytem is 309,900 lineal feet, or almost 59 miles, of which 133,200 lineal feet or 25 miles are channel outfall levees. The areas provided protection from salt water flooding are the same as those protected by the Inboard Levee Plan alternative, but additional protection of the salt pond areas from fresh water flooding is provided by the channel levees. Drainage facilities are the same as those required for the Inboard Levee Plan alternative. The alignment for the Inboard Levee Plan with Channel Levees is shown on Plate 21.

4. Outboard Levee Plan

The Outboard Levee Plan alternative also envisions a series of perimeter levees extending from San Francisquito Creek in the west to Coyote Creek in the eastern sector of the study area. This alternative, in addition to providing salt water flooding protection to inland areas, would provide protection to the outlying salt pond areas. The areas afforded protection amount to approximately 14,000 acres, of which 7,300 acres are common to the other alternatives. The remaining 6,700 acres are predominantly salt pond areas lying outboard of the existing inboard levee system. For the most part, the proposed alignment would utilize the alignment of the existing outboard levee system. The total length of the outboard levee alternative is 318,400 lineal feet or 60 miles. Within this length are 147,200 lineal feet or 28 miles which are common to the Inboard Levee Plan alternative. The alignment adopted for the outboard levee alternative is shown on Plate 22. Levee KK, 8.1 miles in length, which contains Sub-area K, containing a gross area of 2,164 acres, has been included in the National Wildlife Refuge as adopted. Therefore it has been deducted from the Outboard Levee Plan cost computations described in Chapter X.

New drainage facilities proposed for the Outboard Levee Plan in addition to those required by the Inboard Levee Plan are largely confined to the outlying salt pond areas which are protected by perimeter levees. Except for Alviso, all other areas within the proposed alignment are considered to have adequate drainage facilities. These include existing systems or those which are programmed for construction within the immediate future. For those areas requiring internal drainage facilities, a series of total pumping plants or stations with a bank of pumps are proposed. Pumping requirements and pumping facilities considered necessary to serve these areas are as follows:

Drainage Area	Location	Areas Served (Acres)	No. of Pumping Stations Required	Maximum Combined Capacity (cfs)
A	Palo Alto	276	1	120
B	Mountain View-Sunnyvale	408	1	110
C	Mountain View-Sunnyvale	2196	4	940
D	Mountain View-Sunnyvale	1515	3	650
O	Alviso	4402	5	1100

Drainage areas cited above are shown on Plate 19.

5. Outfall Channel Levee Plan

For purposes of cost comparison, consideration was given to an alternative which provides only for the construction of levees along all major outfall channels and sloughs in the study area, providing fresh water flooding protection only. Without inboard or outboard levees, all areas would be subject to salt water flooding during periods of extreme high tides or severe storms. The length of levees required for this alternative plan is 235,700 lineal feet or approximately 45 miles. Since inboard and outboard levees are not a part of this alternative, no provision is made for internal drainage.

The Outfall Channel Levee Plan is considered herein only as a means to provide a cost comparison between fresh water and salt water protection, and, therefore, is not further considered in this chapter. These costs are more fully described in Chapter X.

B. DESIGN CRITERIA AND CONSIDERATIONS

Prior to the development of the engineering design criteria for the various levee alternatives previously described, consideration was given to the endemic geologic, hydrologic and hydrographic conditions in the South Baylands study area. In addition, the influence of seismic activity, of fresh and salt water flooding, and of subsidence and settlement were also given prime consideration in the development of criteria for the design and construction of protective works in the study area. The following sections describe the design parameters and criteria developed and used in this study. In addition, in order to achieve a sound and economic engineering design, consideration was given to alternative types of levee construction and to drainage facilities required by each alternative plan. The design parameters are described in the following section.

1. Design Parameters

a. Fresh Water Flooding

Fresh water flooding as differentiated from salt water flooding is the result of inundation of land as a consequence of overtopping of a levee by fresh water, of failure or breaching of a levee along a major outfall channel, or of storm ponding in contained areas under severe storm conditions because of inadequate drainage facilities. For the purpose of this study and report, a 100-year flood was assumed as the design flood. A 100-year flood is a flood which on the average over a long time period can be expected to be equalled or exceeded at least once in 100 years. Design flows of all of the major outfall channels expected from such a flood were presented previously in Section A of this chapter.

For the purpose of designating drainage facilities to handle internal storm waters, a rain storm having a 25-year recurrence interval was used. Required pumping capacities were estimated on the basis of 1.4 times the average inflow of the first hour.

For this study it was assumed that upstream reaches of all major outfall channels would be improved to the extent that levee overtopping or breaching with resulting fresh water flooding of downstream areas would be eliminated. This assumption is necessary because the capacities of existing or programmed drainage systems are presently designed to accommodate only local storm runoff. Any major fresh water flooding originating from upstream sources would have an adverse flooding effect on those areas contained by the various levee alternatives considered. It was beyond the scope of this study to determine the extent of fresh water flooding in each sub-area which would result from the overtopping or breaching of upstream channel levees.

b. Salt Water Flooding

Salt water flooding of low lying areas not benefitted by protective works is largely attributed to tidal action under normal climatic conditions. For areas afforded protection by levees or other works, salt water flooding is possible under catastrophic events such as a severe earthquake or an unprecedented storm. Under these conditions, overtopping and breaching with a consequent localized failure of the levees will result. Levee failure also can result from the action of burrowing animals which can provide a threat of seepage or piping to the levee structure. Although rare, this cause of failure has occurred to certain existing levees located in the study area.

From a review of statistical data and an analysis of tidal heights in the study area, it was concluded that in any given six-month period the highest tide that could be expected would be at elevation 6.2 feet above mean sea level. Consequently, unprotected areas below elevation 6.2 can be expected to be exposed to salt water flooding twice a year. Conversely, any levee failure which could not be repaired within a six-month period would result in salt water flooding within the area otherwise protected to an elevation of 6.2 feet.

For the purpose of this study, a 6.5-foot elevation was used to determine the extent of possible salt water flooding in the study area. The limits of this area are shown on Plate 2. The limits, as shown, were derived from the April, 1971 aerial photography maps provided by the District. The 6.5 foot contour which delineates the limit of natural salt water flooding used in this study is almost coterminous with the 10-foot contour shown on U. S. Geological Survey quadrangle maps of 1961.

c. Tides

Tidal heights in the South Bay south of the Dumbarton Narrows are influenced by several independent factors which, when combined, produce tidal heights that differ from those measured at the Golden Gate Bridge. The geometry of the South Bay and the interaction of incoming and outgoing tides produce most of the observed differences.

In evaluating tidal heights for the study area, a relationship was developed between data measurements made at the San Francisco tidal observation station located at Fort Point for 73 years and the 9-year record obtained at the mouth of Alviso Slough. The development of these relationships and the subsequent determination of tidal heights at Alviso Slough is described in Appendix B. For the purpose of this study, Mean Higher High Water (MHHW) was determined to be at Elevation 4.6 and the highest high tide occurring approximately once in two years, at Elevation 7.0 feet, both measured above Mean Sea Level (Elevation 0.0).

d. Wave Action

In determining an appropriate design height for levees, another important factor to be considered is the height of waves. The South Bay is subject only to wave action generated by wind. For this study, this was the only type of wave considered in determining wave heights since the area is not subjected to waves from passing vessels or to tidal waves produced by earthquakes. Because of the configuration of the Bay, which constricts the South Bay, it is known that tidal waves entering San Francisco Bay through the Golden Gate would be dissipated before they could reach the study area.

To properly predict the action of waves, it was necessary to forecast probable wave heights by first considering deep water waves generated in the vicinity of the Dumbarton Narrows and then by considering shallow water waves generated south of the Dumbarton Narrows. The estimated heights of waves generated in shallow areas required adjustment for shoaling, refraction, and breaker height before a final determination of minimum levee heights could be ascertained.

Techniques which have been developed for the forecasting of wave heights are primarily applicable to deep water waves. Whereas such wave heights can be determined with a fairly high degree of accuracy, this does not hold true for shallow water waves. In the prediction of wave heights in shallow water areas, successive approximations are made from deep water forecasting relationships. In adddition, once the significant shallow water wave height is developed, the required approximations for the effects of shoaling, refraction, and breaker height tend to decrease the confidence level of the values obtained.

The following paragraphs briefly describe the procedures used to evaluate probable wave heights in the South Baylands study area. The final wave heights developed are only an approximation at best. Additional field observations, measurements and data collection should be conducted prior to the commencement of final design. Means to obtain additional field data are described in Part (3) of this Section.

(1) Outboard Levees

For levees proposed to be located on the approximate alignment of the existing outboard levees, consideration was given to deep water waves generated in the vicinity of the Dumbarton Narrows and shallow water waves generated in the marshland areas. It can be assumed that with a strong northwesterly wind blowing down the Bay from the vicinity of Angel Island, strong waves can be expected at the Dumbarton Narrows. These strong waves can then be expected to decrease in magnitude as they cross the marshland areas, where they will be subject to shoaling and additional refraction which will decrease their heights.

In determining probable heights of deep water waves at the Dumbarton Narrows, the following assumptions were made:

Wind velocity = 40 knots (67 feet per second)

Wind duration = 2 hours

Equivalent length of fetch = 10 nautical miles

Using deep water forecasting techniques, the resulting significant wave height is 6.5 feet, with a period of 5.5 seconds, at the Dumbarton Narrows.

In considering the shallow water waves generated in the area south of the Dumbarton Narrows, the following assumptions were made to determine significant wave heights:

Wind velocity = 40 knots (67 feet per second)

Wind duration = Less than one hour

Length of fetch = 25,000 feet

Depth of water = 10 feet

From these assumptions, it was determined that the significant wave height would be 4.2 feet and that when converted to maximum wave height, and then corrected for shoaling, refraction, and breaker height the value would be increased to 5.7 feet. Since this wave height value does not take adequately into account the effects of the energy of the stronger wave passing through the Dumbarton Narrows it was deemed reasonable to increase the wave height to 6.0 feet for the purpose of calculating wave runup.

Wave runup, which is the vertical height above still water to which water will rise on the face of the levee slope, determines the top-of-levee height necessary to prevent wave overtopping and the resultant flooding of inland areas. For outboard levees subject to wave action with resulting wave runup, side slopes of 6 horizontal to 1 vertical and faced with dumped riprap were used. The wave runup value obtained for a slope that is smooth and impermeable including an eight percent correction factor to relate the model study data to prototype, was 7.8 feet. For a riprapped slope this value was reduced by 20 percent, resulting in a wave runup height of 6.2 feet. For the purpose of this study, a final wave runup height of 6.4 feet was selected for outboard levees.

(2) Inboard Levees

For levees proposed inboard of the existing outboard levees, consideration was given only to the height of shallow waves generated in the salt water pond areas. In developing the significant wave height, the following assumptions were made:

Wind velocity = 40 knots (67 feet per second)

Wind duration = less than 30 minutes

Length of fetch = 5,000 feet

Depth of water (salt water ponds) = 8 feet

The effect of shoaling and wave refraction would be negligible because of the relatively constant shallow depth of the salt ponds.

From these assumptions, it was determined that the significant wave height would be 2.4 feet and that when adjusted for breaker height upon striking the levees the value would be increased to approximately 2.7 feet.

From the development of the significant wave height of 2.7 feet, it was then necessary to determine the wave runup. To predict wave runup, side slopes of 6 to 1 and slope protection of dumped riprap were used. The resulting value obtained, including a six percent correction factor to relate the model study to prototype, was 3.45 feet. This wave runup height, which is for a smooth slope, was then reduced by 20 percent, to account for the rougher riprap slope protection, resulting in a final wave runup height of approximately 2.8 feet. For the purpose of this study, a final wave runup height of 3.0 feet was adopted for inboard levees.

(3) Data Collection

As previously pointed out, because of the lack of available wave data pertaining to San Francisco Bay, the foregoing analyses are at best only approximations of probable wave heights which could occur in the study area. For detailed levee designs, extensive field observations and measurements of wind and waves, and, in addition, tidal heights, are required. The following is a brief discussion of the investigations which should be conducted to develop such data.

Basic data requirements on winds and waves include wind speeds, direction, and duration, and heights and periods of waves generated by these winds. Wind speed or velocity data can be obtained by the use of anemometers, while wind direction and duration data can be obtained by the use of wind direction and intensity recorders. Wave height and period data can be obtained by the use of a pressure type of wave recorder which relates pressure variations to wave heights. Other data which should be collected include tidal height measurements and a photographic record of wave shoaling and refraction characteristics.

For the Baylands study area, such a program might involve the recording of wind velocities, directions and durations at the mouth of Guadalupe Slough with a second set of observations being collected simultaneously just south of the Dumbarton Narrows. These observations should be performed as near as possible to the water surface. For wave height and period determinations, the pressure head and recorder should be placed outside of the area where waves begin to curl and break. All data should be recorded on digital tape for future computer processing. Such information would be highly instrumental in developing relationships between deep and shallow water waves in the study area.

During the course of searching for hydrographic data in the South Bayland study area, contact was made with the U.S. Weather Bureau Marine Weather Forecasting Station at Redwood City. This agency reported that no observation stations have been established in the Bay Area to obtain wave data on San Francisco Bay. Interest was expressed, however, in the possibility of joining the District in a cooperative effort to establish such a station in the South Bay.

e. Freeboard Requirements

To prevent levees from being overtopped by waves under extreme conditions such as a combination of a storm and a high tide, it is desirable to add an additional height allowance above the minimum levee heights developed from tide and wave runup data. Wind set-up, which could possibly add from one-half to one additional foot to levee heights should also be considered. To account for these factors a freeboard allowance of 3 feet was assumed.

f. Earthquake Effects

Local historical data indicate that strong motion earthquakes in the past have produced ground failures due to liquefaction and lateral spreading of flow slides into channel areas. A review of the seismicity of the area and earthquake recurrence intervals and magnitudes indicate that earthquakes having a magnitude of 6 to 8 are possible within the reasonably foreseeable future. Damage to or failure of levees at certain locations along the various alternative alignments would probably occur due to high levels of ground surface acceleration. For the purposes of this preliminary study, earthquake forces were accounted for in the levee stability analyses by the application of a horizontal acceleration of 0.2g. This was considered appropriate to represent the dynamic forces imposed by earthquake shaking.

g. Subsidence

Since 1934, the Baylands have experienced three to seven feet of subsidence.

Subsidence of the area should be monitored and additional material should be placed on the levee crests as subsidence occurs. Sufficient room should be allowed for placing at least 2.5 feet of additional fill on top of the levees without substantially increasing the side slopes and causing potentially unstable conditions.

h. Settlement

Settlement, as differentiated from subsidence, is localized settlement due to consolidation or densification of the shallow layers of the foundation soil and to shrinkage and consolidation of levee construction material. The amount of consolidation settlement is directly proportional to the thickness of the Bay Mud deposits underlying the levee alignments. Consolidation settlement results from compression of the soils under the weight of the levee. Estimating settlements along various reaches of the levee alignments took into account the recommended levee heights and the thicknesses of the compressible Bay Mud deposits. For estimating settlements, consideration was given to (1) settlement due to compression of the foundation, and (2) settlement due to shrinkage and consolidation if dredged Bay Mud construction material is used.

If the foundation areas are overexcavated to remove compressible deposits, the settlement in that area due to this cause would be reduced. If compacted earth fill embankment is used for the levees, the settlement due to shrinkage and consolidation of the levee materials would be reduced also. For planning purposes, the settlement estimates have been based on the use of dredged Bay Mud embankment materials and the estimated thickness of the Bay Mud deposits in the foundations have been used. To allow for these settlements during and after construction, crest elevation additions were made so as to provide the finished top-of-levee elevations. Necessary construction elevations to compensate for settlement along each of the various alternative levee alignments are shown on Plates 20, 21, and 22.

i. Groundwater Seepage and Uplift

The groundwater level in the Baylands study area is generally at Mean Sea Level. There is some evidence that it varies with tidal fluctuations. In any event, the groundwater level is expected to be less than 10 feet below the existing ground surface and in some of the lower-lying areas it is at or near the existing surface. The principal effect of shallow groundwater levels on levee construction is in the increased difficulty of mobility of construction equipment for placing and compacting fill materials. For levees constructed of dredged Bay Mud along the existing salt ponds or waterways, the use of floating dredge equipment may provide the most practical method of construction.

Areas where the ground surface is below Mean Sea Level, and which would normally be inundated, may require special protection to counteract effects of seepage under the levees. Such seepage would probably be most noticeable in areas having shallow deposits of sands and gravel. These deposits occur frequently along the existing and abandoned stream channels. Deposits of pervious sand and gravel soils would provide a path for seepage flow into the protected low-land area. In order to avoid the necessity for pumping and seepage pressure relief, it may be necessary in some areas to provide seepage cutoff sections by either excavating a trench through the pervious core section, or by some other means. The use of steel sheet piling is relatively ineffective as a permanent seepage barrier. The location and extent of areas requiring seepage cutoff should be determined by detailed investigation of the areas in which levee construction is to take place. For purposes of this study, the areas outlined on the risk zone map (Plate 14) showing soil profiles having shallow deposits of sand and gravel should be considered as areas having a high potential for seepage flows beneath the levees.

2. Levee Design

a. Crest Elevation Determinations

On the basis of the design parameters previously developed, crest elevations for inboard and outboard levees were determined by combining wave runup and freeboard allowance with a specific tidal elevation. The selection of the specific tidal elevations were based upon the following assumptions and considerations:

- The tidal elevation to be reasonably expected should be such that when an unprecedented wind of high velocity and long duration occurs, the event of a high tide and extreme strong wind do not combine into a single rare event.

- The formation of a deep water wave will require a wind duration of two or more hours, while a shallow water wave will require less than one hour to develop.

- During a two-hour wind duration, a tidal change of three feet could occur, while during a wind duration of one hour or less, the tidal change would be less than one foot.

In light of the foregoing assumption and considerations, a tidal elevation based upon Mean Higher High Water was selected for outboard levees, and for inboard levees the highest average tide elevation in any two-year period was used. Therefore, for preliminary design and planning purposes, the recommended crest heights are:

	Inboard Levees	Outboard Levees
Tidal Height	7.0 feet	4.6 feet (MHHW)
Wave Runup	3.0	6.4
Freeboard	3.0	3.0
Total Height	13.0 feet	14.0 feet

b. Cross-Section Materials

A variety of construction materials are possible for levee construction in the study area. The types considered during the course of this study were dredged Bay Mud, compacted imported fill, steel sheet pile cellular cofferdams, and sanitary land fill. A detailed description of these alternatives is presented subsequently in this section.

c. Side Slopes and Crest Widths

Levee stability is dependent upon the strength of the foundation and the strength of the construction materials used to withstand deformation due to both static loading and seismic loading. Liquefaction of potentially liquifiable foundation soils during earthquake shaking is considered possible when ground surface acceleration exceeds approximately 0.2 g. In the levee stability analyses conducted for this study, a horizontal acceleration of 0.2 g was considered appropriate to represent the dynamic forces imposed by earthquake shaking.

For levees constructed of dredged Bay Mud it was considered that the side slopes should not be steeper than 6 horizontal to 1 vertical. In areas where compacted earthfill of imported borrow materials is used to construct the embankments on foundations having adequate strength, the inclination of the side slopes might be increased. Detailed design of levee side slopes was beyond the scope of this planning study. Much more detailed geotechnical engineering investigations and studies should be made for design purposes.

A 30-foot crest width was used in the design to provide vehicular access for maintenance of the levee system. In addition, 50-foot radius turnarounds spaced every 2,000 feet were provided to accommodate maintenance vehicles and equipment. These standards are in accord with requirements of the District.

d. Types of Levee Construction Considered

Several different types of levee sections utilizing various construction materials are possible for levee construction in the study area. In comparing these alternatives, consideration was given not only to the variation in the characteristics of the materials but also to the source of the materials, the method of construction, the cost, and the environmental impact. The types considered include:

> Bay Mud, dredged, in general, from the salt pond side of levee alignments,
>
> Compacted Imported Fill, constructed with imported select earth fill,
>
> Steel Sheet Pile Cellular Cofferdam, utilizing imported granular material, and
>
> Sanitary Land Fill for portions of the levee alignment.

The use of dumped rockfill was not considered as an alternative because of the lack of suitable quality and quantity of such material in the near vicinity of the study area.

(1) Dredged Bay Mud

The use of Bay Mud, dredged from along the salt pond side of the levee alignment, is the least expensive means of levee construction. This material would provide a homogeneous embankment section having a very low susceptibility to liquefaction and would utilize locally available materials adjacent to the construction site. Dredging of Bay Mud can be done by using either a clamshell or a dragline excavator to excavate mud from areas adjacent to the levee alignments and to pile the materials to the desired levee cross-section. Because the Bay Mud and the underlying shallow deposits of loose granular, cohesionless soils exhibit low shear strengths, side slope determinations are governed more by foundation strength than by the fill characteristics. As indicated previously, to ensure adequate levee stability, side slopes for a dredged Bay Mud section should be no steeper than 6 horizontal to 1 vertical. The use of dredged Bay Mud as a construction material precludes the possibility of compacting the levee embankment because, when excavated, the material is too soft and wet to support compaction equipment. However, it can be expected that even without compaction, the dredged Bay Mud material would probably retain much of the same engineering properties that it had prior to being excavated. This strength characteristic is evident from examinations of the existing levee systems presently in use in the South Baylands study area.

For the purpose of comparing the price per lineal foot of levee for the various types of levee construction considered, it is estimated that the construction of a typical outboard dredged Bay Mud levee, using a 12-foot average height of fill for computation purposes, 6 to 1 side slopes, slope protection consisting of dumped riprap 24 inches thick, a sand and gravel filter course 12 inches thick, and levee crest erosion protection of quarry run gravel 12 inches thick, would be $226 per lineal foot. If, for this section, the layer of dumped riprap were reduced to a 12-inch thickness, as recommended for inboard levees and outboard levees not exposed to wave action, the price would be $172 per lineal foot. Unit prices used to determine these costs are more fully described in Chapter X.

If the height of fill were reduced by one foot, the price per lineal foot of levee would be reduced by approximately 16 percent of the typical outboard section first cited.

(2) Compacted Imported Fill

Through the use of imported select earth fill materials a compacted earth fill levee could be constructed which would result in a homogeneous embankment section. This type of levee section offers the opportunity for more closely controlled construction than the previously considered dredged Bay Mud section. On foundations having adequate strength, inclination of the side slopes possibly could be increased to a maximum slope of 3 horizontal to 1 vertical. Construction of a compacted imported fill levee would require the transport of the imported materials by rail and truck or barge from borrow areas located outside the study area. Construction of the levees would proceed along the innermost alignments and progress outward along previously constructed lengths. Many problems are posed by the construction of this type of levee. One is the problem of locating available sources of borrow material in the near vicinity of the study area without new borrow areas of the size required causing an adverse environmental impact in the South Bay region. Because of the excessive hauling distances involved, obtaining materials from sources outside the study area would not be economically feasible. In addition, access to the construction site would be restricted by the character of use of some of the developed areas in the vicinity of the project, and the consequent environmental conflicts which large-scale earth hauling would impose.

In developing cost comparisons for the compacted imported fill levee, a typical outboard section was selected having a 12-foot height of fill, 3:1 side slopes, slope protection consisting of dumped riprap 24 inches thick, a sand and gravel filter course 12 inches thick, and levee crest erosion protection of quarry run gravel 12 inches thick. For this levee section alternative, the cost per lineal foot was comparable to the dredged Bay Mud section. However, because wave runup is greater on a 3:1 slope than on a 6:1 slope, a greater levee height would be required. This factor was not considered in the comprative cost estimates developed, however. Costs developed for the compacted imported fill alternative include the price of material transport from a borrow source about 10 miles distant from the study area.

(3) Steel Sheet Pile Cellular Cofferdam

The third construction alternative which was considered is the use of cellular cofferdams constructed of steel sheet piles. For this type of levee, the steel sheet piles would be driven through the soft loose surface soils into the underlying stiffer clays and denser sands and gravels. The stability of the levee is derived from the stability of the individual cells which would be filled with imported granular soil materials. For the Baylands area, it is estimated that the probable depth for driving sheet piles would be 40 feet below the existing bottom of the Bay. The top of the cells should be at the minimum top-of-levee elevation, i.e., + 13.0 to + 14.0 feet, plus an additional 2.5 feet to allow for subsidence. For this maximum height, 60-foot sheet pile lengths would be required. To provide a 30-foot effective crest width, the diameter of the cells should be approximately 37 feet. Cell fill material should be fairly granular and free draining so as not to overstress the sheet pile interlocks. Approximately 1000 cubic yards of fill would be required per unit, considering a depth of filling of about 20 feet, the area of the cell, and the area between cells as a unit. Each unit would extend along the levee approximately 42 feet, requiring a volume of filling of approximately 25 cubic yards per lineal foot of levee. Some allowance should be made for settlement of the filling due to consolidation of the soft soils at the base on the inside of the cells. This would be approximately two feet, which would add about 10 percent to the volume previously noted. This does not include any allowance for additional volume due to displacement of mud since it is considered that the mud would be contained within the cell and would not be displaced outside the cell. The weight of steel is estimated to be approximately 32 pounds per square-foot of wall. This would result in a steel weight of approximately 100 tons per cell, or about 2-1/2 tons per lineal foot of levee.

The use of sheet piles is not an economical solution, but there are some favorable factors in the use of steel sheet pile for levee construction. First, the sheet pile wall is resistant to erosion, and slope protection would not be necessary except to protect the top of the filling, which should be surfaced with gravel. Second, this type of levee is much less susceptible to the detrimental effects of liquefaction during earthquakes because of the sheet piles being driven through the shallow surface layers into the underlying stiff clays and dense cohesionless soil layers. However, it is not any better than the earth levee in its susceptibility to settlement due to liquefaction of deep layers.

Although the steel sheet pile cellular cofferdam levee section alternative does have considerable merit with respect to engineering design and construction, the use of such an alternative is not economically feasible for an entire system because of its high cost in materials and construction. However, its use could be considered in localized areas where detailed design studies indicate that earthfill levees are not suitable or in special situations where openings in the levees are to be provided with control gates.

As stated previously the levee filling material should be a fairly granular, free draining material, in order not to overstress the sheet pile interlocks in tension. This precludes the use of dredged Bay muds for most of the filling because of their very low permeability and fine grained characteristics. Also, the silty materials in the Bay Mud would tend to wash out through the interlocks and be lost, causing internal erosion of the levee filling and cavities, which could impair the stability of the levees. The requirement of a pervious filling material would mean that most of the cellular fill should be imported granular material, thus increasing the costs above the use of local site materials. The use of a pervious filling would also mean that the cellular cofferdam levee would probably have substantial leakage unless special treatment were provided to reduce the leakage through the filling and interlocks. Pumping to handle leakage should be anticipated. The design of a cellular cofferdam levee would require detailed study of the site conditions including analysis of possible pumping requirements to handle leakage.

For purposes of developing cost comparisons for this type of levee alternative, a typical outboard section was selected. Including the cost of material transport, the cost per lineal foot for this alternative was estimated to be approximately $1,100, an increase of five times that required for a typical dredged Bay Mud levee section.

(4) Sanitary Land Fill

The use of sanitary fill as a levee construction material is subject to serious question with respect to its permanence and stability. Sanitary land fill, by its basic nature, is weak and compressible, is susceptible to deterioration by decomposition, is fairly pervious, and has limited resistance to erosion. From this standpoint, it is an undesirable construction material for levees intended to protect land from flooding.

However, a massive section of sanitary land fill with an impervious zone and slope protection on the outboard side, might be feasible. This alternative should be studied in detail for each site where sanitary land fill exists and may be considered for use as part of the levee system.

Sanitary land fill materials should not be used as part of the levee system without very careful detailed study and evaluation of the particular land fill area under consideration. It is not known what the stability of sanitary land fill would be under seismic loading conditions during earthquake shaking. However, because of the loose and relatively uncompacted state of such land fill areas, it is expected that they would be susceptible to failure under relatively low levels of earthquake shaking and ground surface acceleration.

Wherever sanitary land fill is used, sections exposed to the Bay or to outfall channels should be protected by a containment structure consisting of dumped riprap underlain by a sand and gravel filter course. For the purpose of this study, the use of sanitary fill was not considered in light of its unknown stability under seismic loading conditions.

e. Recommended Levee Section

On the basis of the foregoing discussion and the economics of engineering design and construction, the dredged Bay Mud levee section was selected to develop cost comparisons for the various alternative alignments considered. The recommended dredged Bay Mud levee section as shown on Plate 23 will have the following features:

(1) Side slopes of 6 horizontal to 1 vertical.

(2) Crest width of 30 feet with 50-foot turnarounds spaced at 2,000-foot intervals along the levee alignment.

(3) Bayside slope protection for inboard levees not exposed to wave acttion will consist of 12 inches of dumped riprap underlain by 12 inches of sand and gravel filter material. Outboard levees subject to wave action will have 24 inches of dumped riprap underlain by 12 inches of sand and gravel filter course. Inland levee slope protection will consist of planted grasses and other vegetation.

(4) Levee crests will have a 12-inch layer of quarry run gravel.

f. Characteristics of Recommended Construction Materials

For the purpose of preliminary design, construction materials were assumed to exhibit the following characteristics:

(1) Bay Mud

Water content = 63%

Dry unit weight = 55 lbs/cu ft

Total unit weight = 90 lbs/cu ft (foundation)
= 80 lbs/cu ft (fill)

Buoyant unit weight = 30 lbs/cu ft

Compressibility factor = 0.20

Angle of shearing resistance = 0^{o}

Cohesion = 500 lbs/sq ft

(2) Riprap for Outboard Levees Subject to Wave Action

Minimum rock size	30 to 40 lbs
Median rock size	240 to 300 lbs
Maximum rock size	1000 lbs

(3) Riprap for Inboard Levees and Outboard Levees not Subject to Wave Action

Minimum rock size	5 lbs
Median rock size	40 lbs
Maximum rock size	160 to 180 lbs

It is important in all cases that riprap be placed on a minimum thickness of 12 inches of sand and gravel filter material to prevent the erosion of the embankment materials from behind the riprap and the subsequent loss of support for the riprap. When riprap layers are thin--18 inches or less--the design of the riprap depends upon the convenience of construction and rock sizes available. The placing of dumped riprap requires care in handling and placement to ensure that the material is placed in reasonably uniform gradation and thickness. The maintenance requirements and cost of keeping slope protection adequate will depend in a large measure on the care with which the material is initially placed and the bedding upon which it is placed.

3. Internal Drainage Design

a. Drainage Systems Considered

For the Baylands study area, various types of systems to handle internal drainage resulting from storm runoff are possible. Each of these alternative systems provides a means for collecting, storing and discharging storm waters into channel outfalls by pumping. Alternative pumping schemes include total pumping with a minimum sump, pumping with an enlarged sump, and pumping at forebays or lagoons. Since most of the developed areas within the study area have individual systems to handle local storm drainage, attention was focused on those areas which are presently partially developed or totally undeveloped. For these areas a total pumping facility with minimum sump storage was generally considered to be the most appropriate because of the associated higher costs for increased storage capacity. However, specific decisions regarding the type of storage can best be made at the time individual areas are scheduled for improvement. For instance, from an environmental standpoint, lagoon pumping may be more desirable in a recreational or park area, whereas, in an area zoned for industrial use, pumping from an enlarged sump or forebay may be the most appropriate solution.

b. Drainage Facilities for Alviso

For the purpose of this study, the provision of internal drainage for the vicinity of Alviso was applied to that area which is between the proposed levee alignment on the north and an extension of the line of Montague Road on the south, and between the Guadalupe River on the west and Coyote Creek on the east, shown on Plate 19 as Area O. For this drainage area, which totals over 4,400 acres, the accumulated internal drainage yield is approximately 65 acre-feet for the first hour of a one-in-25 year rain storm. Assuming that the required pumping capacity should be 1.4 times the average inflow of the first hour, a peak pumping rate of over 1,000 cfs would be required to handle the storm water inflow. To accommodate this inflow, five pumping stations would be required. Each pumping station would be equipped with a bank of pumps rated at a maximum capacity of 250 cfs. This capacity was selected to allow trunk lines to remain 60 inches or less in diameter so as to avoid the additional costs of deeper trench excavation to install larger size lines. Each pumping station would be equipped with a bank of pumps with each pump having a capacity of 20,000 gallons per minute (gpm) at a head of 20 feet. Lead pumps would be electrically driven and the other pumps would be either diesel or propane driven for reliability during power outages. For this study, storm drain collection systems were not included as part of the drainage facilities since such systems are normally included as site development construction items.

c. Drainage Facilities for Outlying Salt Ponds

For the Outboard Levee Plan, consideration was given to providing internal drainage systems for outlying salt ponds in addition to the area in the vicinity of Alviso. In order to size pumping station requirements peak flows were determined on the basis of accumulated internal drainage yields. The maximum capacities and the number of pumping stations required for the outboard levee alternative were described in Section A of this chapter. Pumping facilities required for draining salt pond areas are similar to those described above for the Alviso area.

d. Impact of Alternative Plans on Drainage

(1) Do-Nothing Plan

The impact of the do-nothing alternative with respect to general drainage problems which now exist within the study area is considered to be negligible in light of drainage improvements presently under construction and those planned in the future. With the exception of Alviso, whose drainage problems are serious, all Bayfront cities within the study area are in the process of implementing various construction programs for improving their local drainage systems.

(2) Inboard Levee Plan and Inboard Levee Plan with Channel Levees

Each of these alternatives would give adequate protection from flooding by natural events consistent with the design assumption stated earlier in this chapter. The configuration of the proposed alignments is compatible with the levees that presently exist and should cause no appreciable problems with existing drainage patterns. As stated for the Do-Nothing Plan, general drainage problems will continue to exist; however, the impact of these alternative plans upon drainage will be negligible in light of improvements presently underway and those contemplated in the future. Thus, existing and proposed drainage systems will not be affected by the construction of an inboard levee system.

(3) Outboard Levee Plan

Almost all areas contained between the inboard and outboard schemes presently are salt ponds or natural wetlands. It is probable that little, if any, immediate development will take place that would warrant the need for a drainage system. However, if staged developed should occur, new storm water collection and pumping systems would be required as each subarea is developed. Drainage of these areas could best be accomplished by a series of separate systems since existing or current proposed systems are designed to handle only the storm flows occurring within the existing inboard levee alignment. It would be expected that any development of these outboard areas would be under the jurisdiction of the respective cities and that these cities would be responsible for the orderly implementation and construction of the necessary collection and pumping facilities.

4. Channel Outfall Considerations

a. Backwater Profile Analyses

To ascertain if recommended levee heights would provide adequate protection from fresh water flooding in the area under study, backwater profiles were developed for the Guadalupe River and Alviso Slough for the 100-year design flood (24,000 cfs) under both steady state and dynamic conditions utilizing computer program analyses. Having derived the backwater profile under the traditional steady state conditions, it was found possible to determine the dynamic effects of a fluctuating tide on the backwater profile by use of a computer program developed by Professor James A. Harder of the University of California at Berkeley. This program, considered unique in backwater profile analyses, is capable of translating a flood wave through a channel reach under variable tidal controls. As may be noted on Plate 24, both methods produced comparable results. The dynamic analysis produced a maximum backwater profile which was a little below the steady state condition. This small difference is primarily attributed to the channel storage effect in translating the flood wave.

To predict adequately the maximum water surface profile which would occur during the 100-year flood, two analyses were performed on the existing channel cross-section, which, under present conditions, is heavily silted. The first analysis considered the present condition, while the second analysis assumed the full design cross-section of the channel, expected to exist after channel maintenance dredging has taken place. It was assumed in this analysis that there would be no deepening of the channel but only the removal of material lying on either side of the lowest elevation of the channel. As may be noted on Plate 24, the maximum water surface profile developed from the design cross-section was as much as three feet lower than the profile for the present condition. The profiles thus developed indicate that the recommended levee heights are capable of handling peak flood flows through the study area provided that the channels are kept free of sediments.

b. Evaluation of Channel Outfall Alternatives

During the course of this study, various reports prepared by the District were reviewed and evaluated with respect to channel outfall alternatives for certain areas within the study area. The following paragraphs briefly discuss these alternatives.

(1) Combining Tributary Channels into Main Channel Outfalls

One approach, studied by the District in 1971, was to combine the storm water flows of the southern portion of the Coyote Creek and of the Guadalupe River in the eastern sector of the study area into a single main channel outfall along Alviso Slough. Such an approach would require the diversion of the southern portion of Coyote Creek into the Guadalupe River either in the vicinity of Montague Road or farther north near Alviso. The apparent advantage of such a solution would be the elimination of the need to maintain existing outfalls along both Guadalupe Slough and the northern reach of Coyote Creek. However, a distinct disadvantage to this approach would be economic, because the initial dredging and the right-of-way costs required to divert Coyote Creek would be excessive when combined with the additional cost of having to widen the outfall and increase the maintenance of Alviso Slough in order to control the combined flows of the two tributary channels.

This concept was studied in detail to ascertain if other channels within the study area could be combined into main channel outfalls. It was concluded that such an approach would be impractical in light of the intensively developed areas in the westerly and central sectors of the study area which would have to be traversed.

(2) Channel Diversion into Tidegated Flood Retention Basins

Flood control protection by means of diverting outfall channels into tidegated flood retention basins was also considered. In July 1964, the District completed a report on practical solutions to the control of flooding along the outfall channels of Matadero, Adobe and Barron Creeks in the City of Palo Alto. The report concluded that the existing Palo Alto Flood Basin was inadequate to pass the peak flow of a 100-year-frequency flood (5,200 cfs) safely because of the limited storage capacity of the existing basin. Using the existing 16 tidegates, it was determined that the required storage volume to handle the 5,200 cfs peak flow would be in the order of 3,600 acre-feet. This would require excavating the bottom of the 440-acre basin to Elevation -3.5 and raising the surrounding levees to Elevation + 9.5 feet.

Similar evaluations were given to other possible flood basin schemes for other tributary drainage channels in the study area. Using 100-year flood design flows, it was concluded that such flows would require the construction of extensive basins to retain the flood flows and, in addition, continued maintenance would be required to keep the basins free of sediment build-up. Associated with the need for continued dredging would be the problem of obtaining suitable sites to dispose of the dredged materials.

c. Sedimentation

The effect of sedimentation and the need to provide continuous maintenace dredging of major channel outfalls was evidenced by the results of the previously described backwater profile analyses conducted on the Guadalupe River and Alviso Slough. In the Baylands study area, the deposition of sediments in channel outfalls or tidal sloughs is brought about by the erosion of upstream lands and the recirculation of Bay sediments which are brought upstream by wind, current and tidal action. Erosion of upstream lands generally occurs during periods of heavy rain storms. Eroded soils are transported by storm runoff into natural streams or gullies where they eventually enter into natural or man-made outfall channels. During this process, the heavier soil particles are deposited into the stream or channel bed and the finer particles continue downstream until stream velocities are such that they fall out of suspension. For Bay sediments, a different sequence of events occurs. Fine grained Bay Mud particles are brought into suspension by wind, current or tidal action and are brought upstream into the outfall channels by high tides. When the tides subside the fine grained materials settle.

The foregoing is a simple explanation of the sedimentation process, but its causes and effects are complex. To add to this complexity, local subsidence of the Baylands study area has affected the sedimentation process by decreasing stream and channel gradients, thus allowing additional silting to take place.

In an effort to define the sedimentation problem and to determine the extent of sedimentation which occurs in the Baylands study area, consultation was had with Professor Ray B. Krone of the University of California at Davis. The following is a summation of Dr. Krone's observations and suggested courses of action to cope with the problems of sedimentation in outfall channels. A full description of these observations and the effect of estuarial sedimentation in San Francisco Bay is contained in Appendix C.

Accumulation of Bay Mud that is carried into outfall channels by tidal currents will occur during the major portion of the year when there is little or no stream flow. Deposition of sediments will occur most rapidly near the sides of channels where currents are slow and where the rate of aggregation is enhanced by flow separations at irregularities of the levees or at structures. The rate of resuspension by wind will be reduced in the levees, and resuspension by tidal currents will be limited wherever the currents are slow, such as in the corners of channels and on the insides of bends. Accumulation of Bay Mud will occur, therefore, most rapidly along the sides of channels and near structures and bends.

If channel maintenance dredging is not performed, a natural channel cross-section will develop. This cross-section will include a narrow channel, maintained by tidal flows, and shallow mud flats. These mud flats usually develop and stabilize along the sides of a channel and the deposition progresses until the mud is exposed for significant periods during low tide. During these periods, the surface mud dries and the internal structure of the deposit irreversibly alters to a more dense arrangement. Large cracks develop in the mud surface as the material shrinks in volume, and the strength of the material increases. Further deposition and partial water loss eventually provide conditions suitable for the growth of plants, and the deposit is firmly stabilized against existing normal flow conditions. All stages of these filling and stabilizing processes can be observed in existing Baylands drainage channels.

The degree of sedimentation which occurs annually in the outfall channels of the Baylands is dependent upon the channel cross-section, tidal currents, and suspended sediment concentrations of inflowing waters. Relatively little or no data is presently available for the study area to estimate reasonably the rate of sedimentation which occurs in the existing outfall channels. order to approximate a sedimentation rate to determine annual maintenance requirements, the following assumptions were made.

(1) Time-averaged currents in the channels are 0.26 feet per second, including slack periods.

(2) Maximum currents are 0.8 feet per second.

(3) The channels have smooth walls and no obstructions.

(4) The average water depths are 5 feet.

(5) Time-averaged suspended sediment concentrations averaged over the profile, are 200 milligrams per liter.

(6) The density of the deposits is 1.269 grams per cubic centimeter.

Relationships developed during earlier studies using similar sediments were used to calculate the rate of deposition. From the foregoing assumptions, a value of 0.7 foot per year was calculated as the annual deposition or sedimentation rate to be used for channel maintenance requirements. These annual costs and other operation costs are more fully described in Chapter X.

Sedimentation rates can vary easily in succeeding years because of a changing sediment supply. Winds are the most important factor in the South Bay. Even greater variation will be found if the channel walls are not smooth or if obstructions exist. Near piling, such as those under docks, the sedimentation rate can be several times as rapid as in an open channel. Deposition will be highest near the channel edges and on the insides of turns and less near the center and on the outside of turns. These rates will be sharply increased where the channel is widened or deepened so that the current is reduced.

A more appropriate means to evaluate and determine a reasonably precise sedimentation rate is by the use of a mathematical model which would more fully describe currents, bed shears, and concentrations of suspended sediments. While this approach is somewhat elaborate for a preliminary study, it should be considered in the final design phase.

CHAPTER X

CONSTRUCTION, OPERATION, AND MAINTENANCE COSTS

Estimates of total project costs were made under two general categories: construction costs, which include all costs associated with the construction; and the costs of annual operation and maintenance of the levee and channel systems and related pumping facilities. This chapter describes the cost estimates made for the alternative levee systems and related facilities.

A. METHOD OF CONSTRUCTION

It is anticipated that the construction of new levees would be accomplished over a substantial period of time and woud be done in stages. This would be of particular advantage in areas where the foundation is underlain by compressible Bay Mud deposits. The Bay Mud has a relatively low strength and is a very sensitive material in that it loses most of its strength when it is disturbed and remolded. Therefore, any disturbance of the foundation muds will tend to cause them to lose whatever strength they have. This loss of strength is usually manifested during a filling operation by the formation of a mud wave ahead of the filling due to displacement of the mud. The depth of displacement varies with the stiffness of the mud and the rate of filling. For very rapid filling on soft mud deposits, the displacement could be through the entire depth of the Bay Mud to the stiffer layers below. For a slower rate of filling, the displacement will be less. Depths of displacement of 60 to 75 percent of the thickness of the soft mud are not uncommon. This results in an increase from 20 to 35 percent in the volume of fill material required.

Although Bay Mud loses strength during disturbance and remolding, it is also highly thixotropic and regains its strength quickly upon being allowed to remain undisturbed for a comparatively short period of time. Bay Mud also gains strength during consolidation due to the increased density of the deposit under the compressing load.

The techniques of construction probably will vary with the site conditions along various reaches of the levees. In some areas, particularly along channel areas where the dredged material is being piled up to form the levee, in order to prevent overloading of the channel banks it may be necessary to proceed slowly in order to allow the foundation soils to gain strength by consolidation. If levees were to be constructed in the outer limits of the salt ponds as in the Outboard Levee Plan, the softer muds on the Bay bottom would undoubtedly experience greater displacement for a given rate of filling than the stiffer muds along the inboard line of levees. Therefore, at outboard levee locations, a comparatively slow rate of filling probably would be appropriate to minimize the displacement of the mud.

The Bay Mud material recommended for levee construction would be dredged from areas adjacent to the alignment of each levee, usually in salt pond areas. The material would be excavated by a clamshell or a dragline excavator working from a floating barge. Normally the material will be handled only once since there are dredges available which have up to 130 feet of clear reach over the side of the barges. Because of the large amount of material to be removed, a lightweight magnesium clamshell bucket could be used to increase the load of each cycle. If necessary, the dredges can be equipped with a longer clear reach, but at the sacrifice of efficiency. One restriction on the size of dredge used is the vertical clearance, since the dredges must pass under the power transmission lines in the area. In order to gain entrance to the salt ponds, the dredges must be moved through an earthen lock. Such locks exist at most of the salt ponds.

The material would be placed in lifts, with the permissible height of each lift being determined by trial fills made at the time of final design. The permissible lift height will probably vary from one location to another, depending upon the water content of the material and upon foundation conditions. The material placed in each lift will densify with time and the foundation material will consolidate under the weight of the overlying materials being placed.As the Bay Mud material dries and consolidates it will regain much of the strength properties that it had prior to being excavated.

Imported quarry run gravel materials will be added to the crest of each levee to provide protection from erosion and to provide traction for maintenance vehicles. This material can be placed by end-dump from trucks or it can be unloaded by clam from a barge. If trucks are used, the tires should be of a special low friction design. Care must be exercised in traversing the levees with trucks so that the wheel loads do not cause failure of the weak foundation material.

The sand and gravel filter and riprap courses placed on the outboard side for wave protection can be placed by clam from materials dumped from trucks on the top of the levee or from materials brought to the job site by barge. The slope protection materials should be placed as the embankment is raised. A drainage channel along the inboard side of the levee is required to collect water which might result from wave spray over the top of the levee. This channel can be formed from the borrow area for the levee.

The pumping structures can be constructed conventionally. The excavation can be protected by a cofferdam of sheet piling and granular fill. Water seeping into the excavation and flowing mud will be the most difficult problems to be encountered.

B. UNIT PRICES

1. General

The applicable unit prices used in this study were obtained by reviewing unit prices from various sources, including estimating guides, material suppliers, and recently constructed levees. The unit prices included all of the contractor's costs, including mobilization, demobilization, and general overhead and profit. For imported materials, the unit price also includes the cost of transport from sources outside the study area. The same unit prices were applied to both inboard and outboard levees, considering that minor changes in work conditions will offset each other. The unit prices utilized are shown in Table 16.

The service life of the levees is considered to be indefinite if care is exercised during construction in placing levee materials, and proper and continuous maintenance is carried on thereafter. For pumping facilities a service life of 20 years was assumed for mechanical and electrical equipment and 50 years was assumed for pumping station structures. These service lives are considered to be minimal if care and continuous maintenance is exercised after construction.

2. Levees

The unit price shown for dredged Bay Mud embankments includes the rough shaping of the sides of the levee but not compaction, since the material is too soft. Since the material will be wet, no allowance will be needed for dust control. The unit price includes all other items of work which will result in the finished levee section.

TABLE 16

UNIT PRICES USED TO DETERMINE CONSTRUCTION COSTS OF LEVEES

(January 1972 Price Level)

1.	Rights-of-Way	$ 2,500/acre
2.	Clearing and Grubbing	500/acre
3.	Levee embankment from Bay Mud	0.80/c. y.
4.	Levee embankment from imported borrow (assuming a 10-mile haul distance)	4.00/c. y.
5.	Imported Granular Fill (including material transport)	5.60/c. y.
6.	Sheet Piling (MP 110) in Place	5.00/s. f.
7.	Filter Material	8.00/ton
8.	Riprap Rock	9.25/ton
9.	Gravel for Roadways	8.00/ton

The source of riprap material is near Watsonville, California about 44 railhaul miles from Alviso. The price includes rail transportation loading and unloading in special trucks or barges, transportation by truck or barge to the construction sites, and placement on the side slopes. No closer source of riprap supply was determined during this study. A more distant quarry, near Napa, could be used with barge transporation to the site. The unit cost from Napa by barge may be slightly less than the cost by rail from Watsonville, but it was deemed prudent to use the higher value in this estimate.

The source of quarry-run gravel is assumed to be from a borrow area in the vicinity of Hollister, about 50 railhaul miles from Alviso. Other sources of suitable gravel filter can be found in Pleasanton and Napa. The gravel could be transported to the site by barge from Napa and by rail from Pleasanton. Rail or barge transportation should be encouraged to minimize truck movement in the vicinity of the project area.

3. Drainage Systems and Structures

The criteria for the planning of the drainage systems was described in Chapter IX along with factors affecting the cost of pumping facilities. These factors which form the basis of the costs presented are as follows:

a. Each pump station would have electrically driven lead pumps, and the balance of the pumps would be diesel- or propane-driven for reliability during power outages.

b. The maximum capacity of the pumping stations would be approximately 250 cfs in order to allow trunk sewer sizes to remain 60 inches or less in diameter and thus avoid added costs for deeper excavation to install even larger trunk sewers. It is assumed that each section would have a bank of pumps, with each pump having an approximate capacity of 20,000 gpm at a head of 20 feet.

c. Costs for the extension of roadways and electric power lines to the pumping station sites are not included, since such improvement costs are normally considered as part of land development costs.

The costs of additional pumping facilities to serve lands not now being provided drainage are presented in Table 17. These costs are based upon the factors previously mentioned.

The costs of pumping stations were developed from reviewing the cost of recently constructed pumping stations and from reports supplied by the District. Drainage costs not included are those for the major storm drain collection sytems. Generally, these costs may be from two to three times that of the pumping station. The design and

TABLE 17

ADDITIONAL PUMPING FACILITIES AND COSTS ANTICIPATED TO SERVE THE BAY LANDS STUDY AREA

	LOCATION	AREA SERVED IN ACRES	FIRST* COST	ANNUAL COST
OUTBOARD LEVEE SYSTEM:				
A	Palo Alto	276	$ 225,000	$ 28,400
B	Mountain View-Sunnyvale	408	210,000	26,300
C	Mountain View-Sunnyvale	2,196	1,440,000	199,000
D	Mountain View-Sunnyvale	1,515	760,000 260,000	105,000 34,000
INBOARD LEVEE SYSTEM:				
O	Alviso	4,400	1,730,000	235,000
	TOTALS	8,795	$4,625,000	$ 627,700

*Excludes 5% allowance for miscellaneous construction.

costs for the collection systems are normally included in related site development costs.

C. CONSTRUCTION COST INDEX

1. General

The construction costs shown are the costs which would be expected if competitive bids from contractors were requested as of January 1, 1972. As it is anticipated that it will be several years before any work commences, this section of the report provides guidelines for future escalation of costs.

2. Cost Trends

The cost of construction has risen appreciably in the past few years. At the previous high rate, before the enaction of wage and price controls, it appeared that the trend of construction costs was increasing quarterly. As it is too soon for the long-term results of the wage and price control program to be known, the trends shown here are based on previous historical experience.

3. Cost Index

The most recent quarterly cost roundup available for this study is *Irrigation and Hydro Cost Indexes for the West,* published by Engineering News Record in December 1971. From 1968 to October 1971, the indexes for earthwork canals rose an average of 6.5 percent per year. It is believed that this rate for canal excavation would be equivalent and applicable to future escalations of unit prices for the levee embankment portion of the work. For pumping plants, the escalation rate for the same period varies from seven percent for structures to nine percent for pumps and electrical equipment. For the purpose of escalating the costs provided herein, it is thought that nine percent would be conservative and fairly representative for the future projection of costs. After the effects of the wage and price control program are known, these factors should be reassessed.

D. CONSTRUCTION COST ESTIMATES

1. General

Construction cost estimates were prepared for the Inboard Levee Plan and for the Outboard Levee Plan. In addition, estimates were prepared for the Inboard Levee Plan with Outfall Channel Levees, and for the Outfall Channel Levee Plan. These estimates are presented by each section of levee in Tables 18, 19, 20, and 21. The term "Total Direct Cost" represents the estimate of costs to the contractor for performing the work.

TABLE 18

INBOARD LEVEE PLAN
SUMMARY OF CONSTRUCTION COSTS

LEVEE	DIRECT COSTS(1) LEVEES	DIRECT COSTS(1) PUMPING STATIONS(2)	TOTAL	ENGINEERING CONTINGENCIES & DISTRICT EXPENSES (3)	R/W COSTS(4)	TOTAL CONSTRUCTION COSTS
A	$ 8,780,000	–	$ 8,780,000	$ 2,370,000	$ 430,000	$11,580,000
B	3,330,000	–	3,330,000	900,000	180,000	4,410,000
C	6,460,000	–	6,460,000	1,740,000	350,000	8,550,000
D	3,130,000	–	3,130,000	850,000	180,000	4,160,000
E	2,970,000	–	2,970,000	800,000	150,000	3,920,000
F & G	1,770,000	–	1,770,000	480,000	100,000	2,350,000
H	3,570,000	–	3,570,000	960,000	200,000	4,730,000
I & J	10,420,000	$ 1,820,000	12,240,000	3,300,000	580,000	16,120,000
K	1,430,000	–	1,430,000	390,000	80,000	1,900,000
TOTAL	$41,860,000	$ 1,820,000	$43,680,000	$11,790,000	$ 2,250,000	$57,720,000

(1) Includes 5% allowance for miscellaneous construction
(2) Pumping stations are not considered as a District cost
(3) 27% of total direct costs
(4) At $2,500 per acre

TABLE 19

OUTBOARD LEVEE PLAN
SUMMARY OF CONSTRUCTION COSTS

	DIRECT COSTS(1)					
LEVEE	LEVEES	PUMPING STATIONS(2)	TOTAL	ENGINEERING CONTINGENCIES & DISTRICT EXPENSES(3)	R/W COSTS(4)	TOTAL CONSTRUCTION COSTS
AA	$11,840,000	$ 240,000	$12,080,000	$ 3,260,000	$ 590,000	$15,930,000
BB	6,170,000	220,000	6,390,000	1,730,000	310,000	8,430,000
CC	12,580,000	1,510,000	14,090,000	3,800,000	650,000	18,540,000
DD	4,900,000	–	4,900,000	1,320,000	260,000	6,480,000
EE	2,970,000	–	2,970,000	800,000	150,000	3,920,000
FF & GG	1,770,000	–	1,770,000	480,000	100,000	2,350,000
HH & LL	14,220,000	1,070,000	15,290,000	4,130,000	750,000	20,170,000
II & JJ	10,420,000	1,820,000	12,240,000	3,300,000	580,000	16,120,000
MM	1,430,000	–	1,430,000	390,000	80,000	1,900,000
TOTAL	$66,300,000	$ 4,860,000	$71,160,000	$19,210,000	$ 3,470,000	$93,840,000

(1) Includes 5% allowance for miscellaneous construction

(2) Pumping stations not considered as a District cost

(3) 27% of total direct costs

(4) At $2,500 per acre

TABLE 20

INBOARD LEVEE PLAN WITH CHANNEL LEVEES
SUMMARY OF CONSTRUCTION COSTS

	DIRECT COSTS(1)					
LEVEE	LEVEES	PUMPING STATIONS(2)	TOTAL	ENGINEERING CONTINGENCIES & DISTRICT EXPENSES(3)	R/W COSTS(4)	TOTAL CONSTRUCTION COSTS
L	$10,070,000	–	$10,070,000	$ 2,720,000	$ 500,000	$13,290,000
M	5,600,000	–	5,600,000	1,510,000	310,000	7,420,000
N	13,500,000	–	13,500,000	3,650,000	740,000	17,890,000
O	4,900,000	–	4,900,000	1,320,000	260,000	6,480,000
P	2,970,000	–	2,970,000	800,000	150,000	3,920,000
R & S	1,770,000	–	1,770,000	480,000	100,000	2,350,000
T	15,220,000	–	15,220,000	4,110,000	810,000	20,140,000
V & W	10,420,000	$ 1,820,000	12,240,000	3,300,000	580,000	16,120,000
X	1,430,000	–	1,430,000	390,000	80,000	1,900,000
U	4,490,000	–	4,490,000	1,210,000	230,000	5,930,000
TOTAL	$70,370,000	$ 1,820,000	$72,190,000	$19,490,000	$ 3,760,000	$95,440,000

(1) Includes 5% allowance for miscellaneous construction
(2) Pumping stations are not considered as a District cost
(3) 27% of total direct costs
(4) At $2,500 per acre

TABLE 21

OUTFALL CHANNEL LEVEE PLAN
SUMMARY OF CONSTRUCTION COSTS

	DIRECT COSTS(1)					
LEVEE	LEVEES	PUMPING STATIONS	TOTAL	ENGINEERING CONTINGENCIES & DISTRICT EXPENSES(2)	R/W COSTS(3)	TOTAL CONSTRUCTION COSTS
LL	$ 2,870,000	–	$ 2,870,000	$ 770,000	$ 160,000	$ 3,800,000
MM	4,420,000	–	4,420,000	1,190,000	240,000	5,850,000
NN	9,190,000	–	9,190,000	2,480,000	500,000	12,170,000
OO	4,900,000	–	4,900,000	1,320,000	260,000	6,480,000
PP	2,970,000	–	2,970,000	800,000	150,000	3,920,000
RR & SS	1,770,000	–	1,770,000	480,000	100,000	2,350,000
TT	14,890,000	–	14,890,000	4,020,000	780,000	19,690,000
UU	7,170,000	–	7,170,000	1,940,000	390,000	9,500,000
WW	1,890,000	–	1,890,000	510,000	100,000	2,500,000
XX	1,430,000	–	1,430,000	390,000	80,000	1,900,000
TOTAL	$51,500,000	–	$51,500,000	$13,900,000	$ 2,760,000	$68,160,000

(1) Includes 5% allowance for miscellaneous construction
(2) 27% of total direct costs
(3) At $2,500 per acre

The term "Total Construction Cost" represents the "Total Direct Cost" plus the cost of engineering, District overhead for performing the work, right-of-way and contigencies.

2. Elements of the Estimate

a. Land and Right-of-Way

The cost of purchasing land or obtaining easement rights over the land which must be obtained for construction of the levees and appurtenances is estimated at an average of $2,500 per acre. Since most of the land involved is under one ownership and has not changed ownership in recent times, it was not possible to determine the current market value of the land by conventional means. The cost of right-of-way, however, represents only a small percent of the overall cost of a flood protective levee plan, and changes in value of the land would not materially alter the estimated totals for the alternative plans considered in this study.

b. Special Construction Features

There are several locations where, in order to complete construction of the levee system, special features may be required along the levee alignments, where existing drainage structures may require modification, and where culverts should be extended. When final design is undertaken, other situations may be found where a change from the standard levee cross-section should be made or a particular drainage problem will be encountered. In order to provide sufficient funds in the estimate for these items, the total cost of levee construction was increased by five percent.

c. Engineering, District Overhead, and Contingencies

The cost of engineering includes all work required for preliminary design, soil borings and laboratory testing, final design, and preparation of construction drawings and contract specifications. Also included are costs for all work associated with inspection, supervision, and management of the construction contract. For engineering, an eight percent allowance over the construction cost was assumed.

District overhead cost is assumed to be four percent of the construction cost. This is an allowance for the expense of the District during the planning, preliminary design, final design, and construction supervision.

An allowance for contingencies has been included as 15 percent. This is an amount that is set aside for unforeseen costs which may arise during the preliminary and final design stages and during construction. This amount was chosen in lieu of a higher amount because the project is relatively simple to construct.

Thus, the amount for engineering, District expenses and contingencies totals 27 percent.

3. Costs Not Included in the Estimate

a. Roads, Utilities, and Bridge Costs

The project costs do not include moneys for roads, utilities, internal drainage, and bridges in the areas protected by the levees, which normally would be included as a general internal development cost. The only amounts identified for internal drainage are the pumping station costs, but these are not included as a District expense.

b. Escalation

As previously indicated, all costs must be escalated to the proposed year of construction. This item should not be overlooked as the earliest time that construction of the first levee unit could take place is probably three years from a decision to proceed. This represents a possible 20 percent increase in cost.

E. OPERATION AND MAINTENANCE

1. Levees

In order to determine a reasonable cost for annual operation and maintenance of the levee systems, several sources of data were reviewed. One source utilized was the Department of Water Resources Bulletin No. 167, *Pilot Levee Maintenance Study, Sacramento-San Joaquin Delta,* which states:

"Present-day annual levee maintenance costs in state maintenance areas range from $800 to $2,500 per mile, depending on the location, type of section, and condition of the levee. The additional cost of maintaining a structurally sound, revetted levee that is free of major encroachments, if trees and shrubs were retained on the waterward slope, is estimated to be $600 per mile per year, using specialized equipment. Such additional cost to make the levee suitable for other purposes should be borne by interests other than flood control"

This publication is a comprehensive report on experienced maintenace costs for levees along the Sacramento River Delta. From this report and from subsequent information received from other agencies, it was deemed prudent to allocate approximately $2,500 per mile for levee maintenance. This amount is less than the actual amount of $3,000 per mile allocated by the District for the maintenance of the levees along San Francisquito Creek and Stevens Creek, but savings in maintenance cost will accrue when the length of levees being maintained is increased by more than ten times. If trees and shrubs were planted on the landward side of a levee, and the levee were used for multiple purposes, it is assumed that the additional costs to make a levee suitable for other purposes would be borne by interests other than the District. Table 22 presents the cost of levee maintenance for the inboard and the outboard levee plans.

In order to maintain the gradient of the outfall channels so that the design flood flows can pass to the Bay, maintenance dredging is required. An alternative would be the continued raising of the levee elevations to contain the flood flows, but this would be undesirable from the standpoint of adjacent properties. Maintenance dredging, however, is undesirable to the extent that it destroys the ecological balance that is built up in the channels over a period of years. Therefore, the dredging can be done periodically--say every five years--rather than annually, and in a manner which will minimize disturbance of ecologically important tidal slough eyebrows. The guidance of an ecological expert should be sought in carrying out this sensitive maintenance task.

2. Outfall Channels

Maintenance of channels by dredging was found to be a difficult item for which to determine a finite cost. However, an amount should be allocated each year for dredging even though dredging may not be performed annually. Alviso Slough, which is the downstream portion of the Guadalupe River, is dredged periodically by the Santa Clara County Department of Public Works in order to provide navigation clearance for the boat harbor at Alviso. Guadalupe Slough is maintained by the District. The cost of dredging the Guadalupe Slough between 1967 and 1970 was $735,000 or $56,000 per mile. This cost amounted to approximately $0.60 per cubic yard of material excavated.

Another problem requiring sensitive handling is the disposition of dredged material. Although beyond the scope of this study, it is mentioned as a problem requiring study and solution.

For the Inboard Levee Plan approximately eight miles of channels will require dredging involving nearly 82,000 cubic yards per year. Assuming a unit price of 60 cents per cubic yard, based on recent dredging experience, this will mean an annual expense of $49,200. Annual maintenance requirements for the Outboard Levee Plan will involve the dredging of over 20 miles of channels comprising over 411,000 cubic yards of material at a yearly cost of $246,800. This cost includes the annual dredging of Guadalupe Slough which is estimated at approximately $105,800. If a suitable site for disposing the dredged material cannot be obtained near the channels, the unit cost of dredging might be increased as much as three or four times. A breakdown of channel maintenace costs for the inboard and outboard levee alignments is shown in Table 22 along with other annual operation and maintenance costs. The costs shown are on an annual basis although, as stated

TABLE 22

SUMMARY OF ANNUAL OPERATION AND MAINTENANCE COSTS

INBOARD LEVEE PLAN					OUTBOARD LEVEE PLAN				
LEVEE DESIGNATION	LEVEES	CHANNEL MAINTENANCE	PUMPING STATIONS(2)	TOTAL ANNUAL COSTS	LEVEE DESIGNATION	LEVEES	CHANNEL MAINTENANCE	PUMPING STATIONS(2)	TOTAL ANNUAL COST
A	$15,000	$ 1,400	–	$ 16,400	AA	$ 20,000	$ 7,800	$ 28,400	$ 56,200
B	7,000	5,700	–	12,700	BB	12,000	17,350	26,300	55,650
C	13,500	5,050	–	18,550	CC	23,250	23,525(1)	199,000	245,775(1)
D	7,000	1,600	–	8,600	DD	10,750	28,050(1)	–	38,800(1)
E	6,500	1,650	–	8,150	EE	6,500	28,100(1)	–	34,600(1)
F & G	4,000	2,100	–	6,100	FF & GG	4,000	28,550(1)	–	32,550(1)
H	7,750	10,650	–	18,400	HH & LL	29,250	92,375(1)	139,000	260,625(1)
I & J	21,750	15,200	$235,000	271,950	II & JJ	21,750	15,200	235,000	271,950
K	3,000	5,850	–	8,850	MM	3,000	5,850	–	8,350
TOTALS	$85,500	$49,200	$235,000	$369,700		$130,500	$246,800	$627,700	$1,005,000

(1) Includes cost ($105,200) for annual dredging of Guadalupe Slough from inboard alignment to Bay outfall

(2) Not considered as a District expense

previously, actual dredging should be performed on a less frequent basis.

3. Pumping Stations

For the purpose of determining annual operation and maintenance costs for pumping stations, the following factors were used: mechanical and electrical equipment at a uniform capital recovery of 20 years at 6 percent; structures at a uniform capital recovery of 50 years at 6 percent; and operation and maintenance allowance at $40 per unit of horsepower. Annual operation and maintenance costs for pumping are shown in Table 22.

F. COST OF DO-NOTHING ALTERNATIVE

The Do-Nothing alternative, i.e., the existing levee situation as described in Chapter IX and shown on Plate 18, was considered as an alternative for purposes of cost comparison. In order to evaluate the possible costs of such an alternative it could be assumed that the entire privately owned area susceptible to salt water flooding would be purchased at the current market value. The area involved lies between the 6.5 foot elevation and the alignment of the inboard levee system and has a net acreage of 6,457. This includes all of the community of Alviso and portions of Sunnyvale and Mountain View. The market value, based on four times the assessed value, is $160,456,000, which is close to $25,000 per acre overall. These figures do not include the governmental installation of NASA or the Naval Air Station, or locally owned public lands. Local floodplain zoning controls, such as those recently adopted by Mountain View, could decrease the extent of undeveloped acreage that would have to be acquired under such a policy. The removal of this area from the tax rolls would result in an annual loss of taxes to the local communities and the County of more than $4,000,000.

As an alternative to purchasing the entire flood-prone area inboard of the inboard levee alignment it would be possible to fill the area to an elevation above the high tide. It is estimated that the amount of fill required to fill the area and provide about three feet of freeboard would be about 65,000,000 cubic yards. The cost of providing this amount of fill material from inland sources, based on unit costs shown in Table 16, would be about $260,000,000.

The filling of the area could also be accomplished by sanitary fill using solid waste generated in the Bay Area. With this type of fill material the area would be limited to essentially non-structural uses such as parks and recreational uses. The area would have to be publicly purchased before filling so the initial cost and tax loss would be as indicated above. The benefits resulting from this use have not been estimated as this was beyond the scope of this study.

The social costs of the Do-Nothing alternative to the flood control problem in the Baylands is in some respects inestimable. The loss of lives--up to 1,300 in Alviso alone--in the event of a 100-year flood cannot be measured in dollars alone. The alternative of relocating residents from the area were it to be filled above the level of high tides also has immeasurable aspects of social and community disruption which greatly exceed the measurable dollar costs. To do nothing with the existing levees may appear at first to be the least costly of the alternatives, but coping with the consequences in a positive and measurable way results in the Do-Nothing alternative becoming the most costly of the alternatives, as summarized below.

G. COMPARATIVE SUMMARY OF COSTS

A summary comparison of the total construction or acquisition costs of the alternative plans considered shows that the Inboard Levee Plan is the least costly and the Do-Nothing alternative is the most costly, assuming the acquisition of all private lands between the 6.5 foot elevation and the Inboard Levee Plan alignment. The figures are:

Inboard Levee Plan	$ 57,720,000
Outfall Channel Levee Plan	68,160,000
Outboard Levee Plan	93,840,000
Inboard Levee Plan with channel Levees	95,440,000
Do-Nothing Alternative (Property Acquisition Only)	$160,456,000

CHAPTER XI

ECONOMIC COSTS AND BENEFITS, AND PROJECT FINANCING

A. CLASSIFICATION OF LANDS IN THE STUDY AREA

Including the open water of the Bay, the study area consists of almost 20,000 acres. The land in the area has been classified as to current use in accord with assessor's records for the 1971-1972 fiscal year. Details provided in assessor's print-outs show areas by standard land use classes for each census tract.

Census Tracts 5046.01 and 5046.02 cover most of the study area as shown on Plate 25. These tracts cover most of the area between the Bayshore Freeway on the west, Nimitz Freeway on the east, and Route 237 on the south. The study area includes small portions of Tracts 5047 (Moffett Field), 5048.01, 5048.02, and 5050. Acreage estimates have been prepared by land use classifications and are shown in Table 23.

Of the 19,792 acres which lie between the 6.5-foot contour and the county line in the Bay, almost 2,000 are already intensively developed. Some 4,200 acres are either in agricultural use or open, and the remaining 13,600 acres are in water, salt ponds, marshes, and miscellaneous.

The Inboard Levee Plan would protect 7,311 acres of the 19,792 total. These 7,311 acres consist of almost all of the developed lands in the area, including all of the agricultural and most of the vacant urban land. Only about ten percent of the land area in the miscellaneous classification is inland of the inboard levee system.

Land between the inboard and the outboard levee systems is almost entirely in salt ponds. There are nominal amounts of developed and urban vacant land, but 6,280 acres out of 6,664 are in salt ponds.

Areas beyond the outboard levee system are largely in salt ponds, marshes, or open water. A large portion of the salt pond area is located in the designated National Wildlife Refuge, which will not require the type of protection provided by a levee system constructed to the design standards developed in this study.

B. VALUE OF LANDS AND IMPROVEMENTS PROTECTED BY ALTERNATIVE PLANS

Plate 26 shows the acreage of land and water areas in the study area by segments and sub-areas. The sub-areas are alphabetically designated in order to relate land areas

TABLE 23

DISTRIBUTION OF STUDY AREA LANDS

LAND USE CLASS	ABOVE INBOARD LEVEE	BETWEEN INBOARD AND OUTBOARD LEVEES	BEYOND OUTBOARD LEVEE	TOTAL
Residential	427	0	0	427
Industrial	817	40	0	857
Transportation, Utilities, etc.	328	106	0	434
Commercial	70	0	0	70
Public, Quasi-Public	201	0	0	201
Sub-Total	1,843	146	0	1,989
Urban, Vacant	821	140	0	961
Agricultural	3,249	0	0	3,249
Sub-Total	4,070	140	0	4,210
Open Space	4	0	0	4
Miscellaneous	1,394	98	424	1,916
Salt Ponds	–	6,280	3,633	9,913
Bay Water	–	0	1,760	1,760
Sub-Total	1,398	6,378	5,817	13,593
Total	7,311	6,664	5,817	19,792

Source: Areas shown are gross acres. Allocation of land is based upon the location of levees and upon census and assessor's classifications.

to alternative plans of protection on a comparative basis.

As general backup information for the study of alternatives, estimates were made of the assessed value of the lands in each of the component parts. Values include state and locally assessed secured and unsecured properties. Although the data were derived from official sources and care was exercised to relate development to assessed values and to sub-areas, the figures are approximate but they are sufficiently representative to be used in comparative analyses.

Acres and assessed values are summarized in Tables 24, 25, 26, and 27, with land areas grouped into lands between the proposed Inboard Levee Plan and the 6.5 foot contour line (lands protected by the inboard levees); lands between the Inboard and Outboard Levee Plans (lands not protected by inboard levees but protected by outboard levees); and lands and water areas beyond the Outboard Levee Plan but within the County of Santa Clara (lands and water areas not protected or confined by any of the alternative levee systems proposed). Area K, that portion of the salt ponds included within the designated National Wildlife Refuge, is included in this latter category.

It will be noted in Table 24 that the average assessed value per net acre in the area between the 6.5-foot contour line and the Inboard Levee Plan alignment is about $6,200 and that assessed values range from a high of $10,969 down to about $845 per acre. These values include only those lands subject to taxation and do not include federal, state or local lands which are non-taxable. Because of this exclusion, the average total value per acre, in terms of all interests, may be considerably higher than that shown. However, the 6.5-foot contour lies below the most intensively developed portion of the Ames Research Center and runs along the tip of Moffett Field, so that the most valuable portion of these installations are above the critical 6.5-foot elevation. If an estimated value of non-taxable lands and improvements below the 6.5-foot elevation of $40,000,000 is added to the taxable totals, the true value at the market level may be more like $200 million rather than the $160 million shown in Table 24 for taxable values only.

Adoption of the Outboard Levee Plan rather than the Inboard Levee Plan makes certain inboard levees unnecessary and therefore adds to the net inboard acreage protected by the Outboard Levee Plan some acreage used by and classified as gross acreage under the Inboard Levee Plan. It is estimated that about 15 percent of the land used for levee right-of-way in the Inboard Levee Plan would be released from levee use by the outboard levee system. As a total of 854 acres is used for right-of-way in the inboard system, 15 percent of this amount or about 128 acres should be added to the gross and net acreage differences between the Inboard and the Outboard Levee Plans to reflect this additional net land. With this addition, the 4,499 gross acres shown in Table 25 becomes 4,627 gross acres and the 3,957 net acres shown in Table 25 becomes 4,085 net acres. These 128 acres released from the Inboard Levee Plan right-of-way are valued at the average

TABLE 24

ACRES AND VALUES, ASSESSED AND MARKET, OF LANDS BETWEEN THE 6.5 FOOT CONTOUR AND THE INBOARD LEVEE PLAN

AREA	ACRES GROSS	NET	ASSESSED	MARKET	ASSESSED VALUE PER NET ACRE
A	682	616	$ 5,014,000	$ 20,056,000	$ 8,140
B	626	565	4,568,000	18,272,000	8,085
D	466	421	4,618,000	18,472,000	10,969
F	573	501	4,023,000	16,092,000	8,030
H	1,085	942	9,768,000	39,072,000	10,369
Q	371	306	1,188,000	4,752,000	3,882
R	505	444	4,066,000	16,264,000	9,158
P	99	64	415,000	1,660,000	6,484
O	441	366	2,913,000	11,652,000	7,959
N	1,315	1,192	2,662,000	10,648,000	2,233
M	1,148	1,040	879,000	3,516,000	845
TOTALS	7,311	6,457	40,114,000	160,456,000	6,212

Source: Gross and net acreages are from engineering estimates as shown on Plate 26. Assessed Values are from Santa Clara County Assessor's Data, March 15, 1971. Market Value is equal to four times assessed value. Net acres excludes land used by levees and drainage channels. Values per net acre are computed.

TABLE 25

ACRES AND VALUES, ASSESSED AND MARKET, OF LANDS BETWEEN THE INBOARD AND OUTBOARD LEVEE PLANS*

AREA	ACRES GROSS	ACRES NET	ASSESSED	MARKET	ASSESSED VALUE PER NET ACRE
C	288	226	$ 83,000	$ 332,000	$ 367
E	455	403	374,000	1,496,000	928
G	1,402	1,315	405,000	1,620,000	308
I	490	460	1,574,000	6,296,000	3,422
L	287	249	83,000	332,000	333
J	1,577	1,304	830,000	3,320,000	637
Subtotals	4,499	3,957	3,349,000	13,396,000	846
Add**	128	128	803,000	3,212,000	6,273
TOTALS	4,627	4,085	4,152,000	16,608,000	1,016

Source: Gross and net acreages are from engineering estimates as shown on Plate 26. Assessed values are from Santa Clara County Assessor's Data, March 15, 1971. Market Value is equal to four times assessed value. Net acres excludes land used by levees and drainage channels. Values per net acre are computed.

* Excluding Area K, a part of the designated National Wildlife Refuge.

** Add allowance for land used by the Inboard Levee Plan but added to the net inboard area by use of the Outboard Levee Plan.

TABLE 26

ACRES AND VALUES, ASSESSED AND MARKET, OF LANDS BETWEEN THE OUTBOARD LEVEE PLAN AND THE 6.5 FOOT CONTOUR LINE*

AREA	ACRES GROSS	ACRES NET	ASSESSED	MARKET	ASSESSED VALUE PER NET ACRE
A, B, C & D	2,062	1,828	$ 14,283,000	$ 57,132,000	$ 7,813
E & F	1,028	904	4,397,000	17,588,000	4,864
G, H & I	2,977	2,717	11,747,000	46,988,000	4,324
L & Q	658	555	1,271,000	5,084,000	2,290
R	505	444	4,066,000	16,264,000	9,158
P	99	64	415,000	1,660,000	6,484
J & O	2,018	1,718	3,743,000	14,972,000	2,179
N & M	2,463	2,232	3,541,000	14,164,000	1,586
TOTALS	11,810	10,462	43,463,000	173,852,000	4,154

Source: Gross and Net acreages are from engineering estimates as shown on Plate 26. Assessed values are from Santa Clara County Assessor's data, March 15, 1971. Market value is equal to four times assessed value. Net acres excludes land used by levees and drainage channels. Values per net acre are computed.

* Excluding Area K, a part of the designated National Wildlife Refuge

TABLE 27

ACRES AND VALUES, ASSESSED AND MARKET, OF LANDS AND WATER AREAS BEYOND THE OUTBOARD LEVEE PLAN

AREA	ACRES GROSS	NET	ASSESSED	MARKET	ASSESSED VALUE PER NET ACRE
W	370	370	$ 107,000	$ 428,000	$ 289
S	237	237	22,000	88,000	93
T	252	252	73,000	292,000	290
U	131	131	38,000	152,000	290
V	903	903	224,000	896,000	248
Water	1,760	1,760	84,000	336,000	48
K	2,164	2,164	625,000	2,500,000	289
TOTAL	5,817	5,817	$ 1,173,000	$ 4,692,000	$ 202

Sources: Gross and net acreages are from engineering estimates as shown on Plate 26. Water areas estimated by reference to total acreage in Census Tracts 5046.01 and 5046.02. Assessed values are from Santa Clara County Assessor's Data, March 15, 1971. Market value is equal to four times assessed value. Net acres excludes land used by levees and drainage channels. Values per net acre are computed.

value of all land protected by the Inboard Levee Plan, as shown on Table 24,or $6,273 assessed value per acre. This adds $803,000 to the assessed value of the net difference in lands protected by the two plans. Added to the $3,349,000 value within this land, the total becomes $4,152,200 or an average of $1,016 assessed value per net acre. This allowance brings the average assessed value per acre up about $170 or about 20 percent.

In contrast to the area inboard of the Inboard Levee Plan alignment, there is relatively little non-taxable development in the area between the inboard and outboard systems. Therefore, the market value of the taxable lands is not subject to upward adjustments to allow for non-taxable investment as was suggested for the inboard areas. In addition, it should be noted that Leslie Salt Company has received county approval of a lower tax levee on ponds under the jurisdiction of the County, under the provisions of the Williamson Act. Also, the City of San Jose has agreed to lower tax bases within the city. If Williamson Act agreements are maintained for a period of years the assessment values could remain below the market level for an extended period. Thus, it is believed the $4,152,000 value is representative of the total current assessed value but that $16,608,000, the computed market value, is below the real market value of the additional lands given protection by the Outboard Levee Plan.

The value of the additional land protected by the Outboard Levee Plan is less than one-sixth as much per acre as the lands protected by the Inboard Levee Plan. The assessed value of inboard areas is over $6,200 per acre, while the additional areas protected by the outboard system are worth an average of only $1,016 per acre. Based upon the current value of the protected land added by the outboard levee system, the District could afford to spend only about ten percent more for the Outboard Levee Plan than for the Inboard Levee Plan.

As shown on Table 26, the overall assessed value per acre protected by the Outboard Levee Plan is $4,154. This compares with $6,212 for lands protected by the inboard system and $846 for lands between the two alignments. Thus, the addition of the lands between the two systems lowers the average value of lands protected by a levee system. If allowance is made for government or other non-taxable lands and improvements protected by both plans, the net effect of the outboard levee system is reduced even more, inasmuch as the non-taxable facilities and lands lie above the proposed Inboard Levee Plan.

The value of land and water areas beyond the Outboard Levee Plan, as shown on Table 27, are the lowest in the study area, being slightly more than $200 per acre. Thus the current assessments indicate that current land values decline in each segment of the Baylands as the Bay is approached.

In both the Inboard and Outboard Levee Plans, all protected land areas are completely enclosed by levees. Because of this complete protection, all of the assessment base represented by the enclosed lands could be tapped to pay for the new works. However, in the plan which combines the Inboard Levee Plan with channel levees, most of the land situated between the inboard and outboard systems is unprotected from tidal action and salt water flooding, except for the partial protection already provided by Leslie Salt Company or others. The lack of an adequate barrier to contain salt water inflows makes these lands more vulnerable to salt water flooding than under the Outboard Levee Plan. In this respect, the inboard system with outfall channel improvements does not provide the same benefits as the outboard system, regardless of its costs.

C. OVERALL LONG-TERM ECONOMIC BENEFITS TO THE COUNTY

The studies of land requirements in Santa Clara County, described in Chapter VI, indicate that growth in the County for the next 50 years could be accommodated without the reclamation of additional lands in the study area. If such lands were to be provided protection, they would be competing for development with other lands in the County which are not subject to salt water flooding and lands which are less likely to suffer disastrous inundation if an earthquake should occur. If other lands are available in the County to satisfy the same needs as protected Baylands might provide, protection of the Baylands would create no net benefits. Only to the extent that additional usable lands are made available by the proposed levee system would it be possible to visualize net land benefits to the County from protective levee systems. In any case, if a plan and program are adopted which include measures which do more than mitigate potential damage to existing development, thereby adding to usable lands in the protected area, the lands enhanced by such protective improvements could bear the cost burden or a significant portion of it in proportion to the resultant benefits. With development, the assessed value of the protected lands would rise and their ability to bear the tax burden or a share of it would be improved.

D. NET SOCIO-ECONOMIC BENEFITS

Costs of recreational development in connection with the alternative levee system have not been included in the basic cost estimates for each of the alternate plans. Therefore, emphasis in the following discussion is on the reasonableness of the alternative plans from the standpoint of the flood control and other non-recreational benefits which the estimated costs will provide.

Because the need for more land in the Baylands for residential, commercial, and other intensive uses is questionable, it is difficult to identify any net social or economic benefit which any of the alternative plans create. Such growth as can be expected in the County can take place somewhere in the County regardless of the construction of protective works along the Bayfront, for, as discussed in Chapter VI, there appears to be sufficient land of all classifications in the County to meet foreseeable needs.

Building on lands protected by any of the levee systems considered in this study would be done at the risk of destruction of a levee section by a major earthquake. Under all plans it is assumed that a major earthquake could rupture the levees and enable fresh and salt water flooding to take place. Under these circumstances, to construct levees which under all other circumstances protect low-lying lands from flooding may lead to new developments on the "protected" land and to great loss of property and of life when an earthquake occurs. On the other hand, to build a protective system at great cost and then let it be known that the land is potentially hazardous would serve to deter development and to make the project less financially practical. In the light of the hazard to the levee system which earthquakes could cause, and the possibility that levees would be breached and flooding would occur, each developer who decidded to use the "protected" land probably would resort to either physical measures to protect his structures as he would have done in the absence of the levees, or would seek to shift a part of the risk through insurance. There could be a double burden on such land uses: the burden of helping to support the cost of the new levees, and the burden of either more expensive construction in the areas contained by the new levees, or of payments to insure a part of the risk. If more land is not needed, and those who use the new land may incur heavy costs of development or of insurance, it would appear that construction of protective levees for land development purposes is questionable. Land areas inside and above the inboard levee system would be least vulnerable to earthquake damage and are among those most likely to develop in the normal course of events. They are also the areas most likely to be able to bear the burden of additional levee protection.

With respect to recreational uses of the area, it appears that uses could be promoted with or without the systems visualized. Land fill at the margin of the dry land area, generally along the inboard alignment, could serve both to prevent tidal intrusion and to provide extensive park areas for general use.

From either a social or economic standpoint, it does not appear that any of the plans considered is needed solely to provide for new economic development in the County. Land needs can be served elsewhere in the County as well and more cheaply and most recreational needs can be satisfied by land fill projects, such as the Mountain View Shoreline Park, which are easy to reach and do not involve intrusion upon areas which are subject to damage by certain types of recreational activity as discussed in Chapter VII. Where localized interests wish flood protection which exceeds what is reasonable in terms of areawide interest, the cost difference between the alternative which affords the special protection and that which is deemed to best provide generalized benefits should be charged to such special interests.

E. COSTS AND LANDS PROTECTED UNDER ALTERNATIVE PLANS

The capital costs and the costs of annual operation and maintenance for the alternative levee plans were presented in Chapter X. These costs were developed and presented on a sub-area basis. Data pertaining to assessed value and market value have been estimated for comparable areas, and in this section of the report the two elements are brought together. All costs are reduced to annual equivalents, so that they may be compared with the assessed value of the lands protected, and the annual burden of costs on current assessed value can be estimated. In the following discussion, the cost of pumping is excluded because it is not considered a District cost.

1. Inboard Levee Plan

The total cost of the Inboard Levee Plan, in present dollars, is estimated to be $55,410,000 exclusive of pumping. This plan protects 6,457 acres with an assessed value of over $40 million. In addition to the capital outlay required, there would be an annual operation and maintenance expense, excluding pumping, of $134,700. If the $55,410,000 capital cost is converted to annual burden on the assumption the money would be borrowed through general obligation bonds with repayment in 50 equal installments of principal and interest at 7 percent, payments would be at the rate of $4,015,000 per year. When the operational budget is added, the total annual requirement would be $4,149,700.

If the total annual burden were to be charged to the assessment base represented by assessed values of the 6,457 net acres protected by the Inboard Levee Plan, the tax per year for 50 years would be $10.35 per $100. This compares with 18 to 25 cents currently levied in the County by the District. It also compares with $10 to $12 per $100 of assessed valuation paid by properties in the County for all purposes.

Among the specific areas protected by the inboard levee system, the potential burden varies widely (see Table 28). Whereas the average for all lands is $10.35 per $100 of assessed value, in two areas the allocated costs suggest a rate in excess of $42.00 per $100 of current assessed value. At the other extreme, two areas would have rates of less than $7.00. If the protected lands were to bear full costs of protection as allocated in Table 28, the lower valued lands would need to experience a much greater development and increase in value than those lands valued more highly at the present time. For the burden per $100 to be equalized, the lands subject to a levy of $42.00 or more would need to increase in assessed value by six times that of the lands subject to a $7.00 or lower levy in order to be on an equal footing.

The total burden of the Inboard Levee Plan appears to be quite great. However, if development takes place, some of the rise in land value might be captured and used to pay the cost of the protective levees. Regardless of this possibility, the burden would be lighter than shown if assessed values rise. If, for example, the average assessed value rose to $10,000 per acre, the tax base would be $64,570,000 and the annual burden

TABLE 28

CAPITAL AND OPERATIONAL COSTS, INBOARD LEVEE PLAN, COMPARED WITH 1971 ASSESSED VALUES, BY LEVEES AND PROTECTED LAND AREAS

	COSTS IN $1,000'S				ASSESSED	ANNUAL BURDEN PER $100
	LUMP SUM	ANNUAL COSTS			VALUE	ASSESSED
LEVEE	CAPITAL	CAPITAL	OMR	TOTAL	$1,000'S	VALUE
A	$11,580	$ 839	$ 16	$ 855	$14,200	$ 6.02
B	4,410	320	13	333	4,023	8.28
C	8,550	620	19	639	9,768	6.54
D & E	8,080	585	17	602	5,254	11.46
F & G	2,350	170	6	176	415	42.41
H	4,730	343	18	361	2,913	12.39
I, J & K	15,710	1,138	46	1,184	3,541	33.44
TOTALS	$55,410	$4,015	$135	$4,150	$40,114	$10.35

Lump sum capital costs and annual operation, maintenance and replacement estimates described in Chapter X, less pumping costs. Annual equivalent capital cost burden computed by use of a 50-year payback period and 7 percent interest. Assessed values from Santa Clara County Assessor's Records. Annual burden per $100 of the base computed by dividing annual burden by the number of $100 units in the assessed value or tax base.

per $100 of assessed value would be $6.43 instead of $10.35. Furthermore, if values continued to rise with more development and with general price inflation, the burden would decline still further, reflecting the fact that the dollar amount of loan repayment remains fixed. It should be noted that many years may pass before any actual use is made of protected land areas, but that the lands may be reassessed immediately to reflect their new status.

If the cost burden were assumed by the four flood control zones whose watersheds drain into the Bay through the Baylands, instead of just by the protected areas described above, the $4,149,700 annual burden would be borne by an assessement base of about $2,900,000,000 ($2,892,000,000 in 1971-72) for an average annual rate per $100 of about 14 cents.

2. Outboard Levee Plan

The Outboard Levee Plan would protect more area than the Inboard Levee Plan. Assuming that Levee KK will not be included in the plan because the area it contains has been included in the National Wildlife Refuge, the total capital cost of the outboard system is $87,670,000 exclusive of pumping (See Table 29). Annual operational costs exclusive of pumping are $377,300 and the total annual burden of maintenance and repayment of capital costs is $6,730,300 per year. With the total assessed value of the lands protected amounting to $43,463,000, the annual burden of this plan, if applied solely to the value of the lands protected, would be $15.48 per $100, over $5.00 per $100 higher than the burden estimated for lands protected by the Inboard Levee Plan. This means that the average burden on the 6,457 acres which would be protected by the Inboard system for $10.35 per $100 assessed value would be raised to $15.48 and all of the additional land areas protected would also pay the $15.48. As can be seen, the Outboard Levee Plan adds far more to cost than it does to assessment base. Specifically, although the acreage protected is increased from a net of 6,457 to 10,462 (excluding Sub-area K), an increase of over 60 percent, the assessed value increases only from $40,114,000 to $43,463,000, or about 8 percent.

As was noted in connection with the Inboard Levee Plan, the cost burden of the protective levees varies among the sub-areas, if allocated directly to land areas benefitted, and only the lands benefitted were to carry the costs. Because of the generally higher cost per dollar of assessed value of the Outboard Levee Plan, the range of burden per $100 of current assessed value is generally higher, rising from $8.13 per $100 in one area to $48.67 per $100 in another.

In this instance, if the average value of the protected lands was raised to $10,000 per gross acre, the total assessed value would be $104,620,000 instead of $43,463,000. The average burden per $100 of assessed value for net usable acres would drop from

TABLE 29

CAPITAL AND OPERATIONAL COSTS, OUTBOARD LEVEE PLAN, COMPARED WITH 1971 ASSESSED VALUES, BY LEVEES AND PROTECTED AREAS

	COSTS IN $1,000'S				ASSESSED	ANNUAL BURDEN PER $100
	LUMP SUM	ANNUAL COSTS			VALUE	ASSESSED
LEVEE	CAPITAL	CAPITAL	OMR	TOTAL	$1,000'S	VALUE
AA	$15,630	$1,133	$ 28	$1,161	$14,283	$ 8.13
BB	8,140	590	29	619	4,397	14.08
CC	16,630	1,205	47	1,252	11,747	10.66
DD&EE	10,400	754	73	827	5,337	15.50
FF&GG	2,350	170	32	202	415	48.67
HH&LL	18,810	1,363	122	1,485	3,743	39.67
II,JJ&MM	15,710	1,138	46	1,184	3,541	33.44
TOTALS	$87,670	$6,353	$377	$6,730	$43,463	$15.48

Sources: Lump sum capital costs and annual operation, maintenance and replacement estimates described in Chapter X, less pumping costs. Annual equivalent capital cost burden computed by use of a 50-year payback period and 7 percent interest. Assessed values from Santa Clara County Assessor's Records. Annual burden per $100 of the base computed by dividing annual burden by the number of $100 units in the assessed value or tax base.

$15.48 to $6.43. As suggested above, part or all of the costs could be recovered, in theory at least, by capturing part of the rise in land values resulting from the new status of the lands with protection.

If the burden is shared equally among all land areas in the four drainage basins, the $6,730,300 would require a tax rate of about 23 cents per $100 assessed value. This compares with about 14 cents for the Inboard Levee Plan.

3. Inboard Levee Plan with Channel Levees

Under this alternative, as described in Chapter IX, the Inboard Levee Plan would be augmented by outfall channel improvements out to the Bay. In addition, full protection would be given to some 249 acres in Area L which is protected by the Outboard Levee Plan but not by the Inboard Levee Plan.

The cost of the Inboard Levee Plan with Channel Levees has been computed for individual levee alignments. In Table 30 a comparison is made of assessed values by sub-area, as was done in the preceding tables which present comparative data for the inboard and outboard systems. Exact comparison is made difficult by the fact that the channel improvements carry fresh water to the Bay but do not fully protect the land areas lying between the inboard and outboard alignments. Thus, if the entire area is claimed as being protected, the value of the works is overstated, whereas, if only the lands fully protected (the inboard system plus 249 acres of Area L) are included, no credit is given to the fact that the salt pond areas are more adequately protected from fresh water flooding than without the channel improvements.

If only the fully protected areas are included in the areas benefitted, the assessed value is $40,197,000 and the annual burden is $17.77 per $100. If the salt pond areas are included, the assessed value is $43,463,000 and the annual burden is $15.48 per $100. Thus, even with the inclusion of the salt ponds, the burden per $100 is still very high. The added protection provided by this alternative is from fresh water flooding of the salt ponds. This protection is in accordance with the design standards used in this study, but it may be a higher degree of protection than what is required for salt production only.

As with the Inboard and Outboard Levee Plans, specific allocation of costs to lands protected under this plan results in widely different dollar burdens per $100 of current assessed values. The range of difference is the greatest of the three plans, starting at $6.96 and rising to $53.73.

If the burden is borne by the four District zones, the annual outlay would be 24.63 cents per $100, just slightly greater than the 23.21 cents per $100 for the Outboard

TABLE 30

CAPITAL AND OPERATIONAL COSTS, INBOARD LEVEE PLAN, WITH CHANNEL LEVEES, COMPARED WITH 1971 ASSESSED VALUES, BY LEVEES AND PROTECTED AREAS

	COSTS IN $1,000'S				ASSESSED VALUE $1,000'S	ANNUAL BURDEN PER $100 ASSESSED VALUE
	LUMP SUM	ANNUAL COSTS				
LEVEE	CAPITAL	CAPITAL	OMR	TOTAL		
L	$13,290	$ 963	$ 25	$ 938	$14,200	$ 6.96
M	7,420	538	29	567	4,023	14.09
N	17,890	1,296	52	1,348	9,768	13.80
O	6,480	470	39	508	1,271	39.97
P	3,920	284	35	319	4,066	7.85
R, S & T	22,490	1,630	158	1,788	3,328	53.73
V & W	13,810	1,000	37	1,037	3,541	45.86
X	1,900	138	9	147		
U	5,930	430	10	440		
TOTALS	$93,130	$6,748	$394	$7,142	$40,197	$17.77

Sources: Lump sum capital costs and annual operation, maintenance and replacement estimates described in Chapter X, less pumping costs. Annual equivalent capital cost burden computed by use of a 50-year payback period and 7 percent interest. Assessed values are for lands protected by the Inboard Levee Plan plus 249 acres in Area L protected by this plan. Assessed values from Santa Clara County Assessor's Records. Annual burden per $100 of the base computed by dividing annual burden by the number of $100 units in the assessed value or tax base.

Levee Plan. As suggested above, the effects of the two plans may be sufficiently different in terms of protection afforded that a cost comparison alone may not be adequate to reveal the true differences. Both plans would place a greater burden upon the four zones than the Inboard Levee Plan would. The increase in land made available, about 60 percent, is closely comparable to the increase in cost, some 58 percent, or 14 to 23 cents per $100 of assessed value.

4. Allocation of Costs to Protected Lands and to the District

The cost analysis of the Inboard Levee Plan with Channel Levees suggests that the costs for channel improvements alone also should be estimated in order to give a measure of the cost of conveying storm runoff waters to the Bay. This runoff is attributable largely to rainfall in the system watersheds. In addition, the problem of subsidence which is caused primarily by the drawdown on the water table level by upland water users, also requires channel levee improvements. If it were assumed that the District had an obligation to channel fresh water flows to San Francisco Bay, regardless of what it would do with respect to salt water flooding, the costs of the channels alone would give a measure in dollars of this obligation.

A system of levees along all major outfall channels alone would cost an estimated $68,160,000 as shown on Table 21. This is equal to $4,938,900 per year in repayment in 50 years at seven percent. If a charge equal to 15 percent of the capital pay-back is added to the annual burden to cover costs of operations, maintenance and repair, the total annual cost for the channels would be about $5,679,700.

If the residents of the four zones, through the District, are obligated to see that fresh water flows are conveyed to the Bay beyond the salt ponds, it would appear that $5,679,700 of the annual cost burden of any plan which accomplishes this result should be borne by the four District zones as a whole rather than solely by the lands protected.

Of the alternative plans considered, only the Outboard Levee Plan and the Inboard Levee Plan with Channel Levees accomplish approximately what the channels alone would accomplish. Therefore, allocation of costs between lands protected and the lands from which storm runoff originates can be made only in terms of these plans.

5. Cost Allocation and the Inboard Levee Plan with Channel Levees

Referring back to Table 30, a total annual cost burden of $7,142,000 is shown for the inboard levee system with outfall channel levees. If $5,679,700 is charged to the four District zones rather than to the lands directly protected, there would be a balance of annual cost of $1,462,300 which the protected lands would pay. With a current assessment value of $40,197,000, the rate per $100 of assessed value would be $3.64 per year. With a rise in land values the burden per $100 would drop progressively lower. With respect to the District zones, the average burden per $100 of assessed value (1971-72) would be 19.6 cents.

The $3.64 per $100 of assessed value could be reduced to $1.00 per $100 of assessed value if the protected lands rose in value immediately to about four times their current level. To reduce the tax rate to 25 cents, exclusive of the 19.6 cents it might bear if included in the broader area to reflect areawide rainfall problems, average values would have to rise by some 14 times. With allowance for a period before full development is attained, the increase in value would have to be much larger.

Although the District might be able to finance the channel levees alone by a 19.6 or 20 cent tax on property, it does not appear likely that the protected lands could increase in value rapidly enough to finance the other levees with a reasonably low tax rate. The extra burden would be on the landowners in the area. This burden, if accepted, would acknowledge that the landowners expect land enhancement and are willing to pay for it.

6. Cost Allocation and the Outboard Plan

The Outboard Levee Plan is similar to the Inboard Levee Plan with Channel Levees, but it does not carry fresh water flows as far into the Bay. With the responsibility of the District and the four zones unchanged, they could be expected to pay for the equivalent of the fresh water channeling, or $5,679,700 of the $6,730,300 annual cost burden. (It should be noted that the difference in the protection from fresh water runoff between the two plans implies a residual liability on the part of the District under the Outboard Plan. No attempt is made here to put a dollar value on it.)

The total annual burden of the Outboard Levee Plan, as shown in Table 29, is $6,730,300. If $5,679,700 of this cost is charged to the four District zones from which fresh water flows originate, the general property tax in the area will rise 19.6 cents per $100. The protected lands would bear the difference between $6,730,300 and the $5,679,700 which is $1,050,600.

The burden on a tax base of $43,463,000 for lands protected by the outboard system would be $2.42 per $100. This is well below the rate for the Inboard Levee Plan with Channel Levees. The lands protected under the Outboard Plan are more fully protected from both salt water and fresh water flooding and should be able to spread the cost burden over a rising price and assessed value level even more easily than would be possible for lands protected from fresh water runoff alone under the Inboard Levee Plan with Channel Levees.

7. Alternative Concepts of District Responsibility

The foregoing discussion of District responsibility is based on the fact that the channelling of fresh water through the salt ponds to the Bay is a responsibility of the District, except on Alviso Slough. If the District levied a property tax on a broad base for this purpose, it might be that the Baylands so protected would be expected to pay for all other improvements. In effect, the District would mitigate in the Baylands the results of upstream runoff by building and maintaining fresh water channels to the Bay.

There is no clear evidence that protective works such as those proposed in the Outboard Levee Plan are necessary in order for the District to fulfill its primary function. A system which provides more than mitigation– offsetting damages for which the District would be deemed responsible-- would result in land enhancement and consequent pressure for intensive land development. In some instances it may be less costly to enhance the value of land than it would be to provide a system which mitigates damages to existing development alone. In the present instance, the Outboard Levee Plan is less costly than the Outfall Channel Levee Plan. It appears to meet most of the fresh water flow problems, and, in addition, fully protects substantial acreages from salt water flooding. Thus, in terms of costs versus benefits it could be selected in preference to the single-purpose channel mitigation plan or the combination Inboard Levee with Outfall Channels Plan.

If a lower cost, dual- or multi-purpose plan provided both mitigation and land enhancement, the District might be able to shed a part of its burden. Prior to construction an agreement could be reached between the District and owners of lands to be protected, in which the landowners would carry a greater share of the burden than residual costs alone would support.

The District obligation would be more modest if historical or legal shoreline margins of the Bay were held to be located where the inboard levee alignment is located. There then would be no need to maintain levees beyond the inboard levee alignment and the length of the protected channels would be reduced. Closely related to this concept would be the contention that improvements, such as salt ponds or any future urban development within them, and levees constructed to contain them or to protect the development, are an encroachment upon tidal lands and are not a responsibility of upstream residents. If this interpretation were to prevail, the share of any cost which the District would bear would be reduced and the share which the landowners would have to bear would be raised. If levees along channels conveying fresh water outflows were terminated near the alignment of the Inboard Levee Plan, channel costs would be reduced and the fixed share of total costs which the four zones would have to bear would decline accordingly.

Of alternate plans considered, only the Inboard Levee Plan reflects such a reduced obligation. Whereas the total annual burden would be $4,149,700 to all parties, the District would assume only that part of the costs necessary to prevent fresh water flooding. All other costs would be charged to the lands benefitted. Until costs are segregated to distinguish those which are incurred to fulfill a hypothetically reduced obligation from total project costs, the concept cannot be illustrated in dollars and tax rates.

F. ALTERNATIVE METHODS OF FINANCING

Federal participation in the financing of levee improvements would be most desirable. Each of the alternative plans considered would qualify for some assistance.

Land enchancement benefits resulting from reduction in the fresh water or salt water flood hazard are treated, for cost-sharing purposes, in the same way as benefits resulting from reduction of flood damages, except when obvious windfall-type benefits will accrue to limited special interests. Projects providing major drainage improvements and increased land use potential are considered to produce benefits to both the limited local interests affected and to the nation as a whole. Cost-sharing in such cases is defined as including local "payment or contribution toward the construction costs of the project equal to at least 50 percent of an amount determined by applying to the total construction costs of the project the ratio of the particular land enhancement benefits involved to total monetary primary benefits as estimated in the evaluation report".

If the outboard alternative provided land enhancement to a few landowners, especially in the area between the inboard and outboard systems, there might be serious limitations on federal cost sharing. Possible differences in federal participation in the different alternatives should be weighed in the selection of a plan.

The current interest rate being used in conjunction with Corps of Engineers flood control projects is five and one-half percent irrespective of the nature of the benefits obtained. Studies are presently underway by the Water Resources Council concerning the use of a seven or ten percent interest rate for federal water resources project evaluation, but no decision has been made on this proposal to date.

As must be obvious, the higher the interest rate used to discount future costs and benefits the less likely benefits can be shown to exceed costs to the satisfaction of the federal government. Unless benefits do exceed costs, there can be no federal sharing of costs. Unless the excess of benefits over costs is substantial, federal participation may be delayed, assuming there are numerous projects competing for limited resources.

State policy is to encourage local governments to plan land use regulations to accomplish floodplain management and to provide state assistance and guidance as appropriate. The State also provides financial assistance to local agencies cooperating in the construction of federal flood control projects through reimbursement of eligible rights-of-way and relocation costs. State policy on this program is being modified to require the sharing of these costs between the State and the local agency.

A major requirement of state financial assistance is that benefits of the proposed improvements will reasonably exceed the costs thereof. Benefits of a land enchancement nature can be attributed and credited to a project if the need for development in the area protected can be demonstrated and if such development is in accord with a locally adopted land use plan.

Emphasis upon land use planning and floodplain zoning by the State suggests that the enclosure of tidal lands within the outboard levee system might be questioned by the State as a warranted alternative to floodplain zoning. The most feasible local financing available for this type of development is the issuance, of general obligation bonds. This source is difficult to exploit, however, because most of the public must be convinced beyond a doubt that it will be benefitted by the project. Not only is there widespread antipathy to additional taxation required to retire general obligation bonds, but there are likely to be serious questions raised about enclosing tidal lands under the Outboard Levee Plan.

Illustrative figures cited earlier in this chapter in connection with the cost of repaying loans were based upon a seven percent interest rate. This relatively high rate reflects the generally prevailing idea of foreseeable rates.

Financial assistance for the construction of levee systems which protect against salt water flooding may be secured from federal and state sources. Such requests would have the best chances for success if there are concurrent zoning programs which limit development in floodplain areas and discourage developments that increase hazards to life and property, and if land enhancement benefits are widely shared. Although government funds for such programs are difficult to obtain, they are probably the key to a successfully implemented levee system. As a start, the Corps of Engineers should be asked to consider, in conjunction with its forthcoming studies of certain outflow channels in the Baylands, the extent to which it could recommend federal participation in a comprehensive levee system such as has been investigated in this study.

CHAPTER XII

FINDINGS

This concluding chapter of this report on the study of the Baylands salt water flood control problem consists of a recapitulation of the major and significant findings. Recommendations for a specific plan and implementation program are not included in this report, for such decisions must be made by the District on the basis of policy issues or factors which are not influenced in toto by the technical findings of this study. The purpose of this study has been to develop technical information which will assist the Flood Control and Water District in a determination of the policy it may pursue and to provide a comparative evaluation of the costs and consequences of each of the alternative plans considered.

A. FINDINGS

The Baylands of Santa Clara County constitute a unique portion of the County with distinctive qualities and characteristics. Here the obligations of the Santa Clara County Flood Control and Water District to protect the lands and people of the County from the hazards of flooding caused by the overtopping of stream channels by storm flows of fresh water are intensified by the problems of salt water flooding caused by high tides and wind-driven Bay waters overtopping existing levees. This problem has been intensified over the past 60 years by the subsidence of the low-lying Baylands from three to seven feet. The community of Alviso, with a population of 1,300, exemplifies the flooding problem as intensified by subsidence. Once situated above mean sea level with a view of the marshlands and Bay beyond, it is now as much as two feet below mean sea level with its Bay view blocked by levees.

Existing levees which are provided and maintained by public agencies are intended primarily to contain fresh water outfall flows and only incidentally provide some degree of protection from salt water flooding. Most of the existing levees which are outboard of the existing inboard system were designed solely to establish and maintain the system of salt ponds situated on former marshlands. They do not provide a full measure of protection from salt water flooding to the Baylands area.

A number of agencies, in addition to the cities fronting on the Bay, have been invested by law with planning and regulatory controls over the use of portions of the area subject to the hazards of salt water flooding. Among the most important of these are the San Francisco Bay Conservation and Development Commission which has adopted a San Francisco Bay Plan. This plan contains a policy that future uses of the vast salt pond area be water-oriented if salt production is terminated. The plan is interpreted by the

Executive Director to require that any protection of low-lying areas behind the salt ponds should be accomplished by levees located between the salt ponds and the land inland from them, rather than between the salt ponds and the Bay.

The Army Corps of Engineers is also charged with regulatory authority over the waters of the Bay and over all diked areas which are situated below former mean higher high water. This includes the salt ponds. The Corps has never approved a permit application that has been denied by the Bay Conservation and Development Commission.

The Planning Policy Committee of Santa Clara County, composed of representatives of the County and of the cities in the County, has adopted a Baylands Policy Plan which recommends that levee improvements be made only where needed to protect drylands appropriate for urban development, and that all water areas be preserved and enhanced in concert with the objectives of the Bay Conservation and Development Commission. A National Wildlife Refuge was approved by Congress and the President in 1972 that includes all of the salt pond and wetland area in the Santa Clara County Baylands east of Alviso Slough.

Although the rate of population growth in Santa Clara County is slower than it was during the period of rapid growth during and subsequent to World War II, it is forecast that it will continue at a greater rate than will the population growth in the Bay Area as a whole. However, demands for land for urban purposes can be met by the use of lands available elsewhere in the County without requiring the reclamation or development of the wetlands in the Baylands study area.

The ecology, and consequent environmental quality, of the Baylands is of special significance. Although less valuable from the standpoint of waterfowl than areas in the North Bay and Delta, portions of the Baylands are extremely valuable as a habitat for shorebirds. The ecologically most important segments of the study area are tidal mudflats and tidal sloughs which shelter and nourish a great variety of aquatic animals, wildfowl, waterbirds, and marshland animals. Management policies to be developed should control the patterns of access and use of the Baylands as a recreational area, retaining some areas as inviolate sanctuaries.

The geology of the Baylands exposes it to two principal hazards. One is the lateral spreading of soil layers and the other is the liquefaction of underlying soil layers. Both conditions can be induced by earthquake shaking, and the area lies between active fault systems in one of the most seismically active areas in the United States. Geologic risk zones have been identified in the area indicating the specific types of hazards which each portion of the area is most likely to experience in the event of a major earthquake. The underlying conditions so identified are also important to decisions affecting the determination of the location and extent of static loading caused by structures and fills.

For purposes of comparative analysis of service, cost, magnitude, and impact, five alternative plans were developed for study. The first was the present levee system (Do-Nothing alternative) composed of a network of inboard and outboard levees containing nearly 16,000 acres within the study area. Existing levee heights vary throughout the study area with the majority of the higher levees being concentrated in the vicinity of developed areas or along outfall channels. Bay Mud dredged from alongside the existing levee alignments constitutes the basic construction material. The existing levee crosssections vary considerably and for the most part do not provide adequate protection against the extreme events of fresh and salt water flooding and earthquake shaking considered in the levee design criteria developed for this study.

The second alternative considered was the Inboard Levee Plan which consists of a series of perimeter levees following for the most part the existing alignment of the inboard levees. This alternative provides no protection for the salt ponds or other wetlands. This system is 34 miles long and protects approximately 7,300 gross acres.

The third alternative considered was the Inboard Levee Plan with Channel Levees which is similar to the Inboard Levee Plan previously discussed. In addition to providing protection to inland areas it also provides fresh water protection to the salt pond areas by the addition of protective levees along all of the major outfall channels. This system is 59 miles in length of which 25 miles are channel outfall levees.

The fourth alternative studied was the Outboard Levee Plan which provides a system of levees located generally along the existing outboard levees on the Bay side of the salt ponds and on the channels. The total length of this system is 60 miles of which 28 miles are common to the Inboard Levee Plan.

The fifth and last alternative developed during this study was the Outfall Channel Levee Plan. Developed solely for comparative purposes, this plan involves outfall channel levees along the full length of all major outfall channels and provides only fresh water protection to adjacent land areas. The total length of this system is about 45 miles.

Levee crest elevations selected were 13 feet for inboard levees and 14 feet for levees exposed to direct tidal and wave action, both measured from above mean sea level. The alternative use of dredged Bay Mud, compacted imported fill, steel sheet pile cellular cofferdams and sanitary land fill was considered. Because of comparative cost and availability advantages, dredged Bay Mud was selected as the most desirable construction material. Bay Mud would cost $226 per lineal foot for a typical outboard levee section and $172 per lineal foot for an inboard levee section. Steel sheet pile cellular cofferdam construction would cost approximately $1,100 per lineal foot, five times the cost of a dredged Bay Mud section.

Total construction Costs for the five alternatives are estimated to be as follows:

Inboard Levee Plan	$ 57,720,000
Outfall Channel Levee Plan	68,160,000
Outboard Levee Plan	93,840,000
Inboard Levee Plan with Channel Levees	95,440,000
Do-Nothing Alternative (Property Acquisition Only)	160,456,000

Annual operation and maintenance costs for the two basic alternatives were estimated as follows:

Inboard Levee Plan	$ 369,700
Outboard Levee Plan	1,005,000

The present assessed value of lands protected by the Inboard Levee Plan is $40,114,000, averaging $6,212 per acre. The assessed value of lands protected by the Outboard Levee Plan is $43,463,000, averaging $4,154 per acre. The value of the additional land protected by the Outboard Levee Plan is less than one-sixth as much per acre as the lands protected by the Inboard Levee Plan.

If the costs of the alternative plans were borne by the four flood control zones whose watersheds drain into the Bay through the Baylands, the annual average tax rate per $100 of assessed value would be about 14 cents for the Inboard Levee Plan, 23 cents for the Outboard Levee Plan and 25 cents for the Inboard Levee Plan with Channel Levees. If the costs were borne solely by the lands directly benefitted, the annual average tax rate per $100 of assessed value would be about $10.35 for the Inboard Levee Plan, $15.48 for the Outboard Levee Plan, and $17.77 for the Inboard Levee Plan with Channel Levees.

Excluding pumping costs, which would not be a District cost, the following provides a comparison of capital, operational, and maintenance costs; assessed value of lands directly benefitted; and the annual burden per $100 of assessed value for the three alternative plans which would provide salt water flooding protection to the Baylands:

Gilliam, Harold *Between the Devil and the Deep Blue Bay*, Chronicle Books, San Francisco, 1969

Santa Clara County Flood Control and Water District, *Report on Outfall Channels for Matadero, Adobe and Barron Creeks*, July 1964.

Santa Clara County Flood Control and Water District, *Report on A Study of Drainage of the Mountain View Bay Front Area and Permanente and Stevens Creeks Outfall Channels*, September 1964.

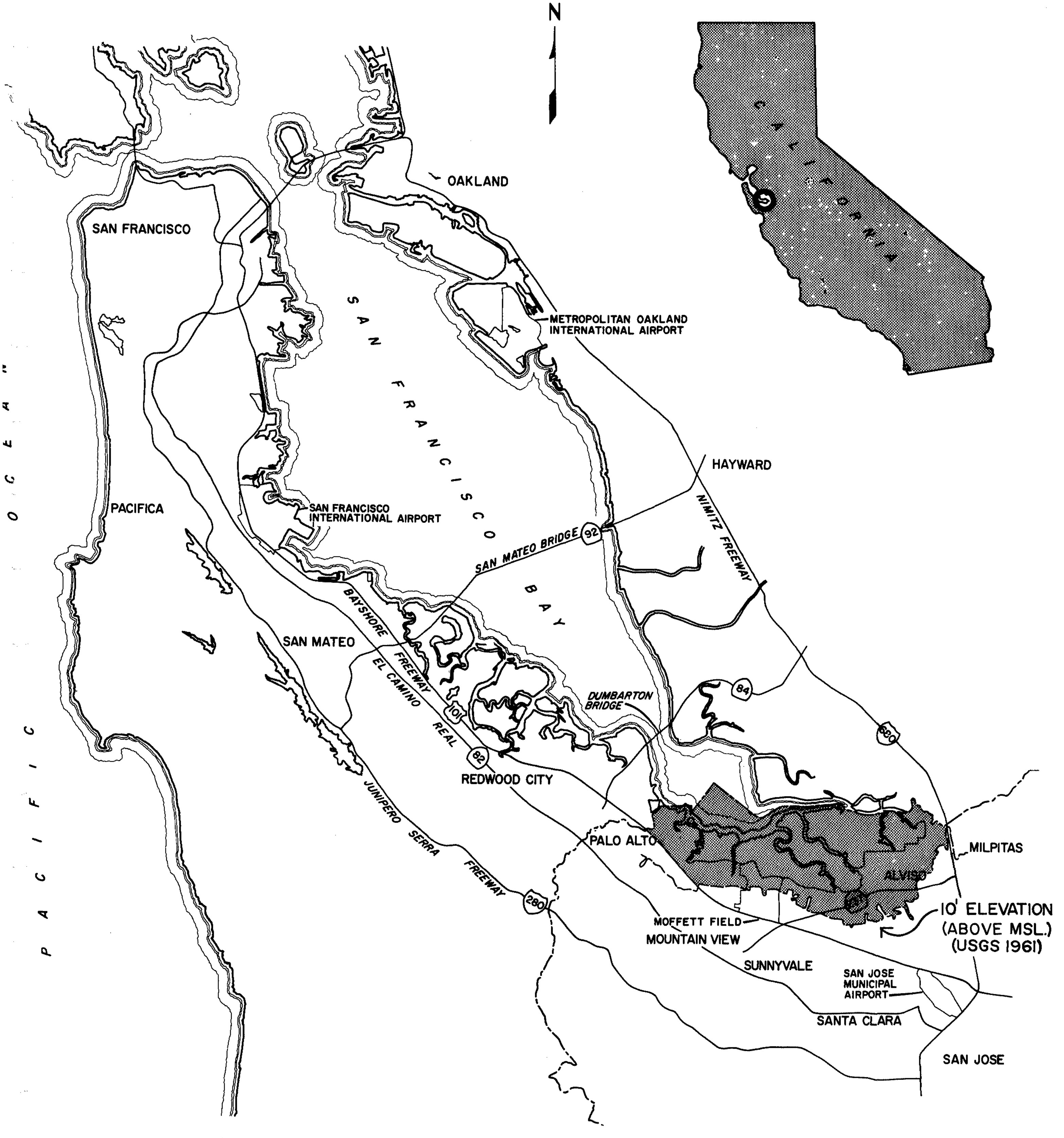
Krone, R. B., *Predicted Suspended Sediments Inflow to the San Francisco Bay System*, Federal Water Pollution Control Administration, Southwest Region, 1966.

Skinner, J. E., *Fish and Wildlife Resources of the San Francisco Bay Area*, Water Projects Branch Report No. 1, California Department of Fish and Game, 1962.

Gustafson, J. F., and Lane, R. S., *An Annotated Bibliography of Literature on Salt Marsh Insects and Related Arthropods in California*, The Pan-Pacific Entomologist 44(4): 327-331, 1968.

Hinde, Howard P., *The Vertical Distribution of Salt Marsh Pheanerogams in Relation to Tide Levels*, Ecological Monographs, Vol. 24, No. 2, p. 209, 1954.

California Department of Water Resources, *Pilot Levee Maintenance Study, Sacramento-San Joaquin Delta*, Bulletin No. 167.



Santa Clara County Flood Control And Water District

Santa Clara County Baylands Flood Control Planning Study

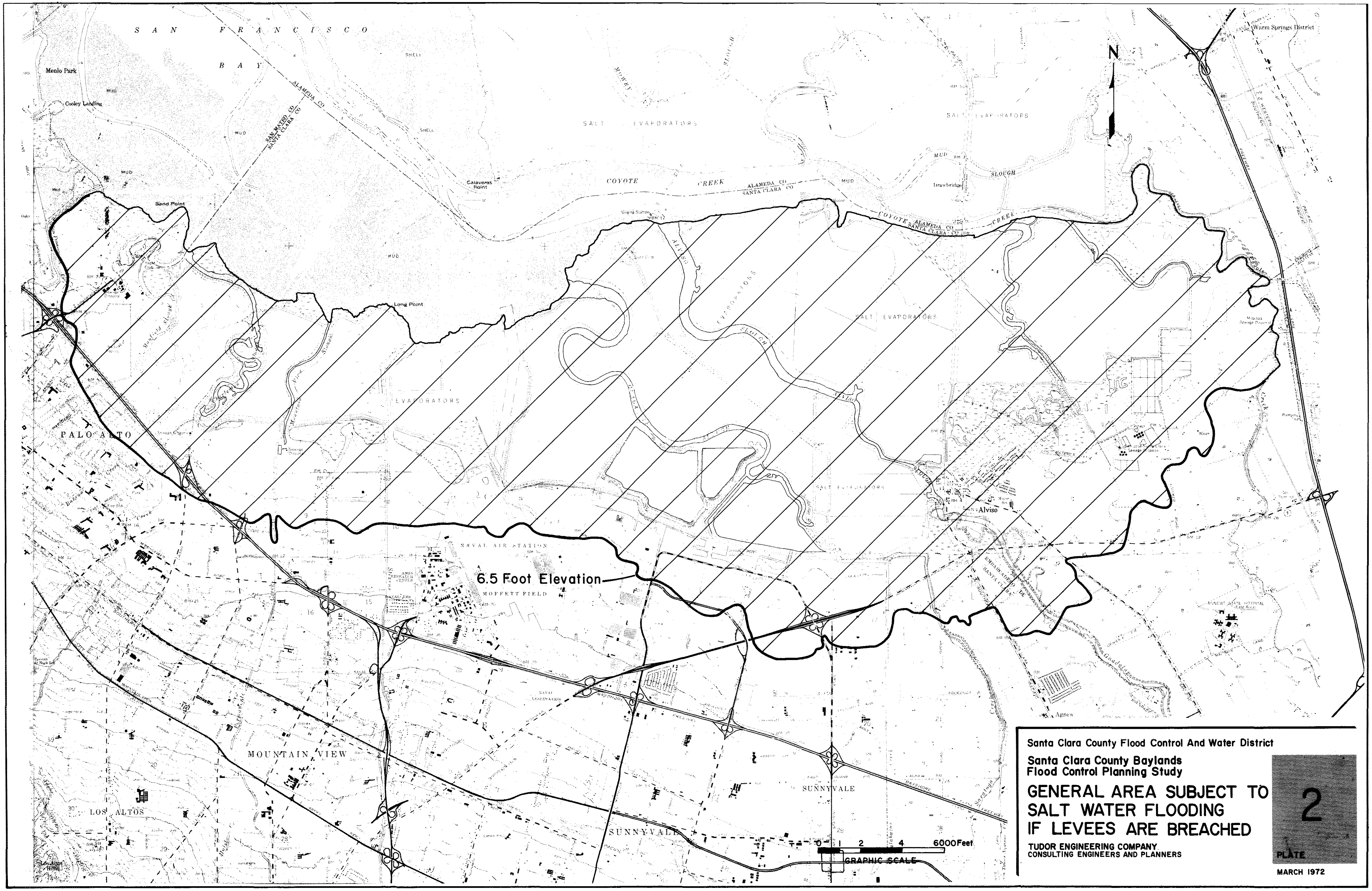
LOCATION OF THE SANTA CLARA COUNTY BAYLANDS STUDY AREA

TUDOR ENGINEERING COMPANY - CONSULTING ENGINEERS AND PLANNERS

1

PLATE

MARCH 1972



Santa Clara County Flood Control And Water District

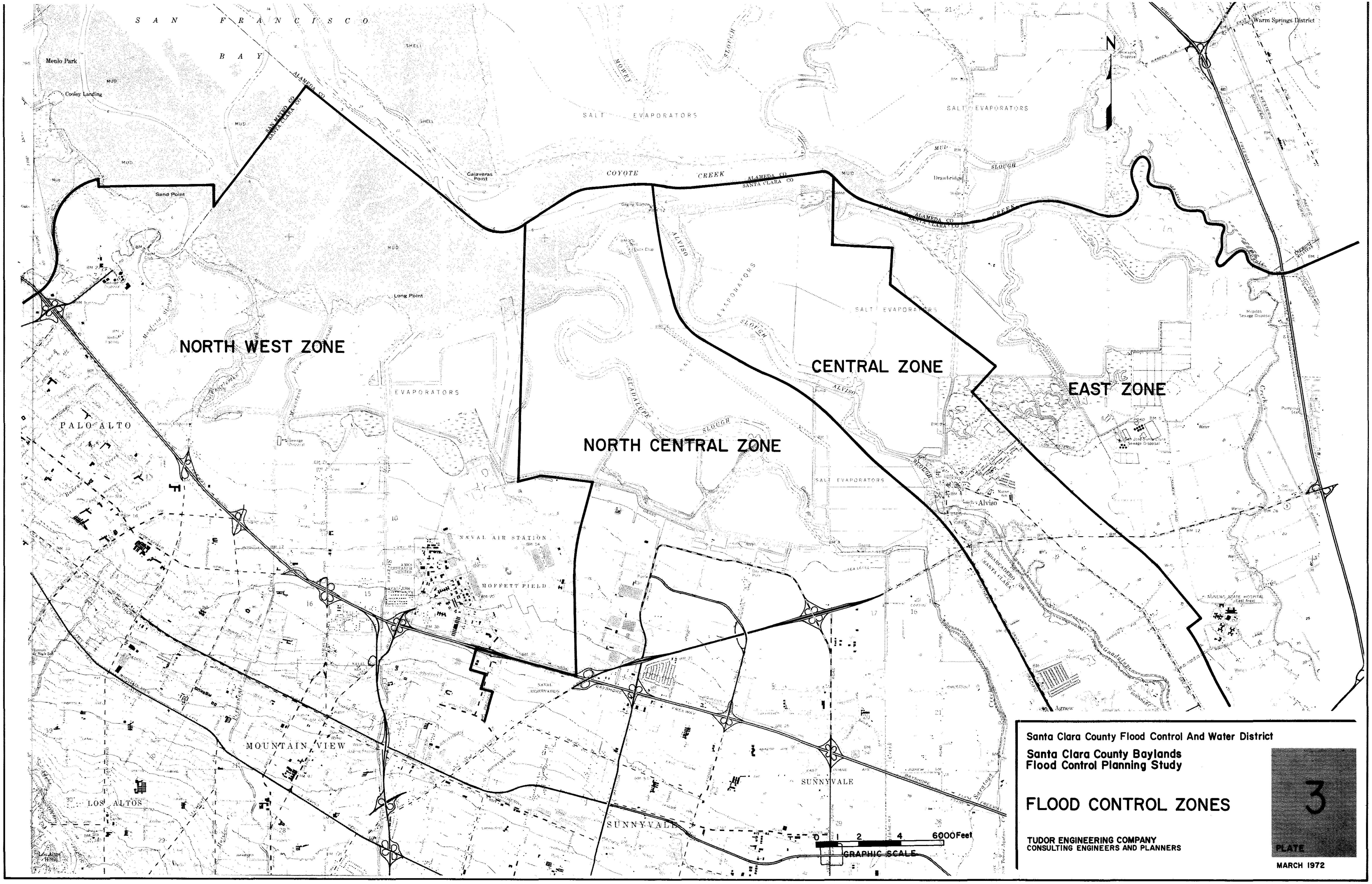
Santa Clara County Baylands
Flood Control Planning Study

GENERAL AREA SUBJECT TO SALT WATER FLOODING IF LEVEES ARE BREACHED

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS

PLATE 2

MARCH 1972



Santa Clara County Flood Control And Water District

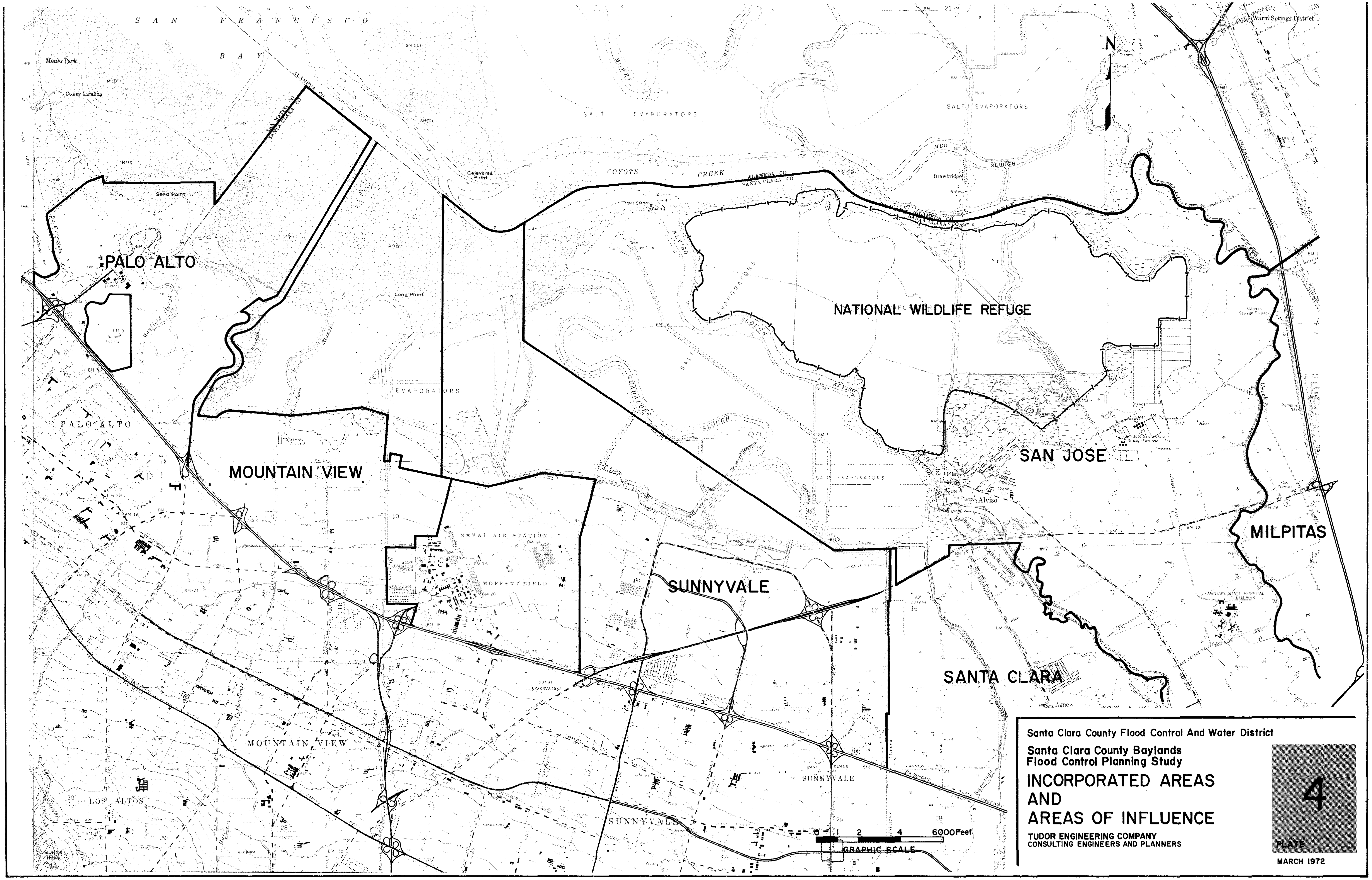
Santa Clara County Baylands
Flood Control Planning Study

FLOOD CONTROL ZONES

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS

3
PLATE

MARCH 1972



Santa Clara County Flood Control And Water District

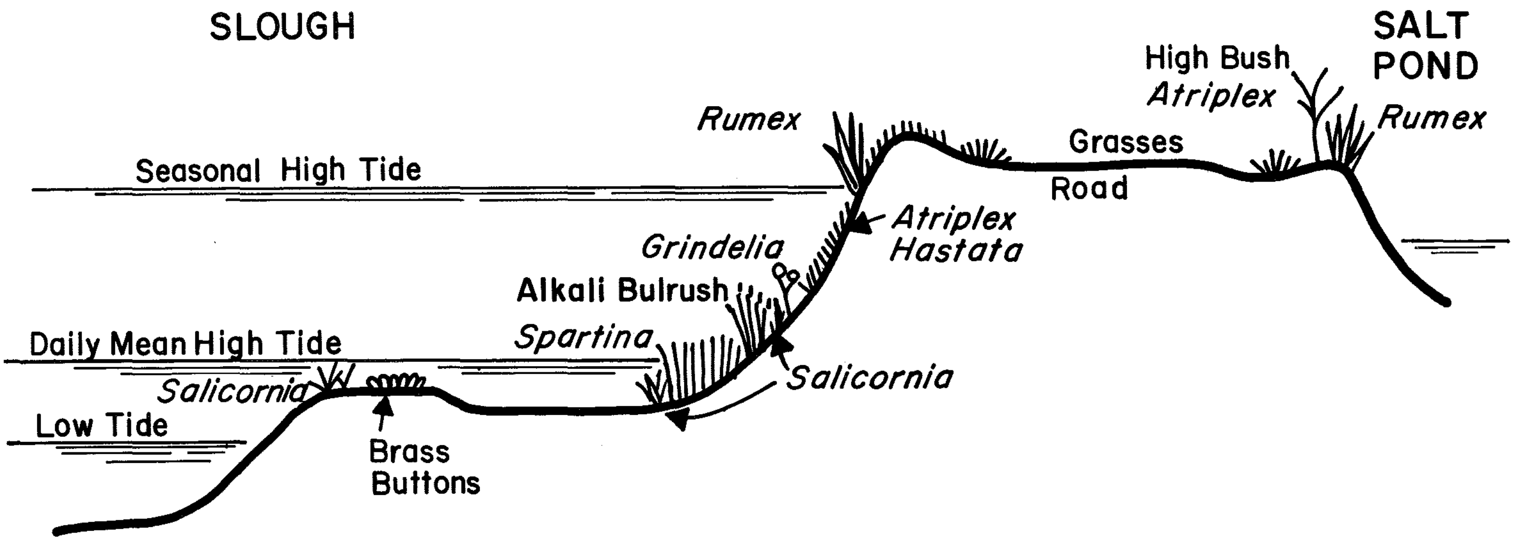
Santa Clara County Baylands
Flood Control Planning Study

INCORPORATED AREAS
AND
AREAS OF INFLUENCE

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS

PLATE 4

MARCH 1972



Santa Clara County Flood Control And Water District

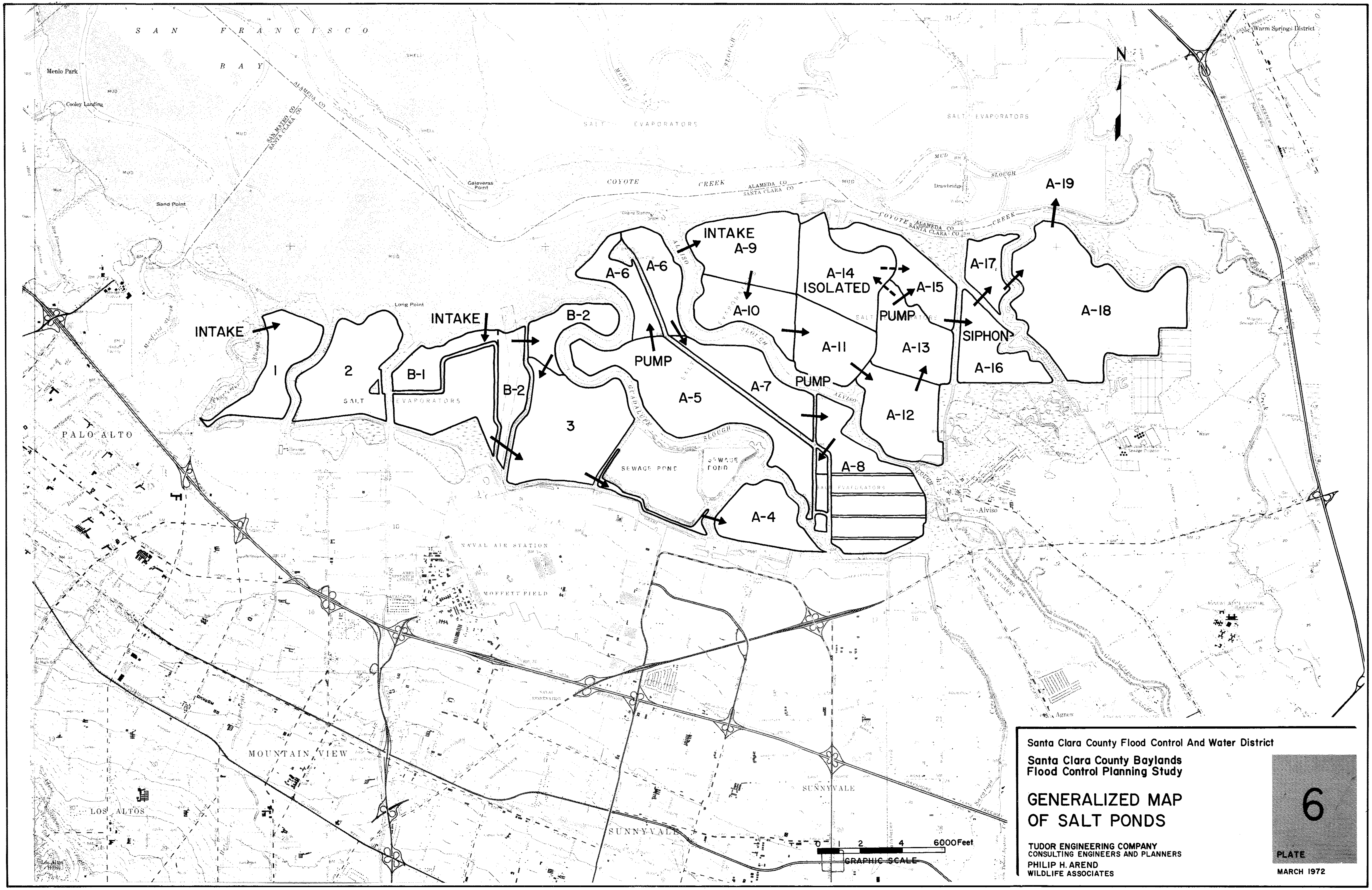
Santa Clara County Baylands Flood Control Planning Study

TYPICAL SLOUGH-
SALT POND LEVEE CROSS SECTION

TUDOR ENGINEERING COMPANY-CONSULTING ENGINEERS AND PLANNERS
PHILIP H. AREND-WILDLIFE ASSOCIATES

5
PLATE

MARCH 1972



Santa Clara County Flood Control And Water District

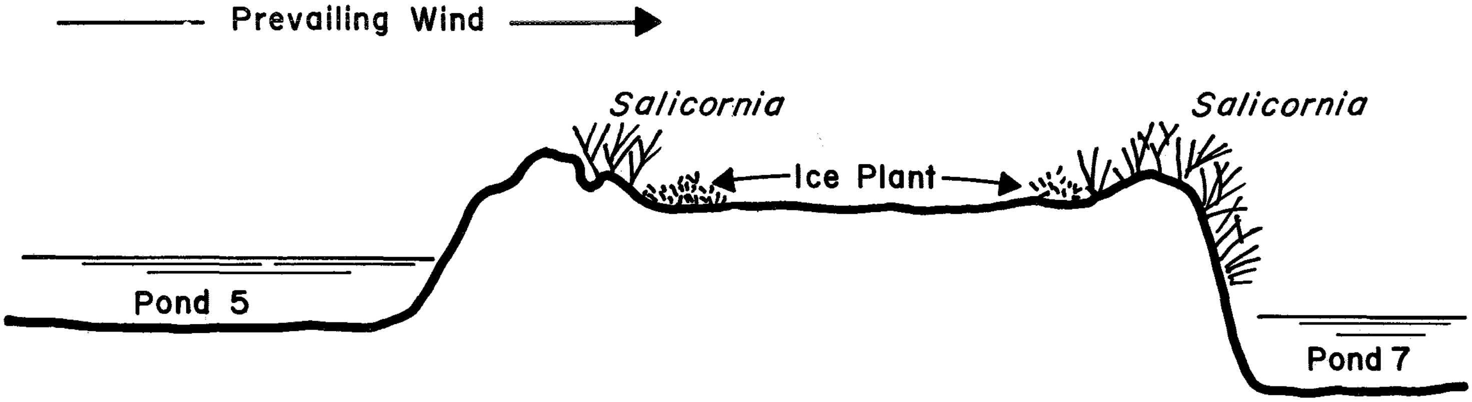
Santa Clara County Baylands
Flood Control Planning Study

GENERALIZED MAP
OF SALT PONDS

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS
PHILIP H. AREND
WILDLIFE ASSOCIATES

PLATE
6

MARCH 1972



Santa Clara County Flood Control And Water District

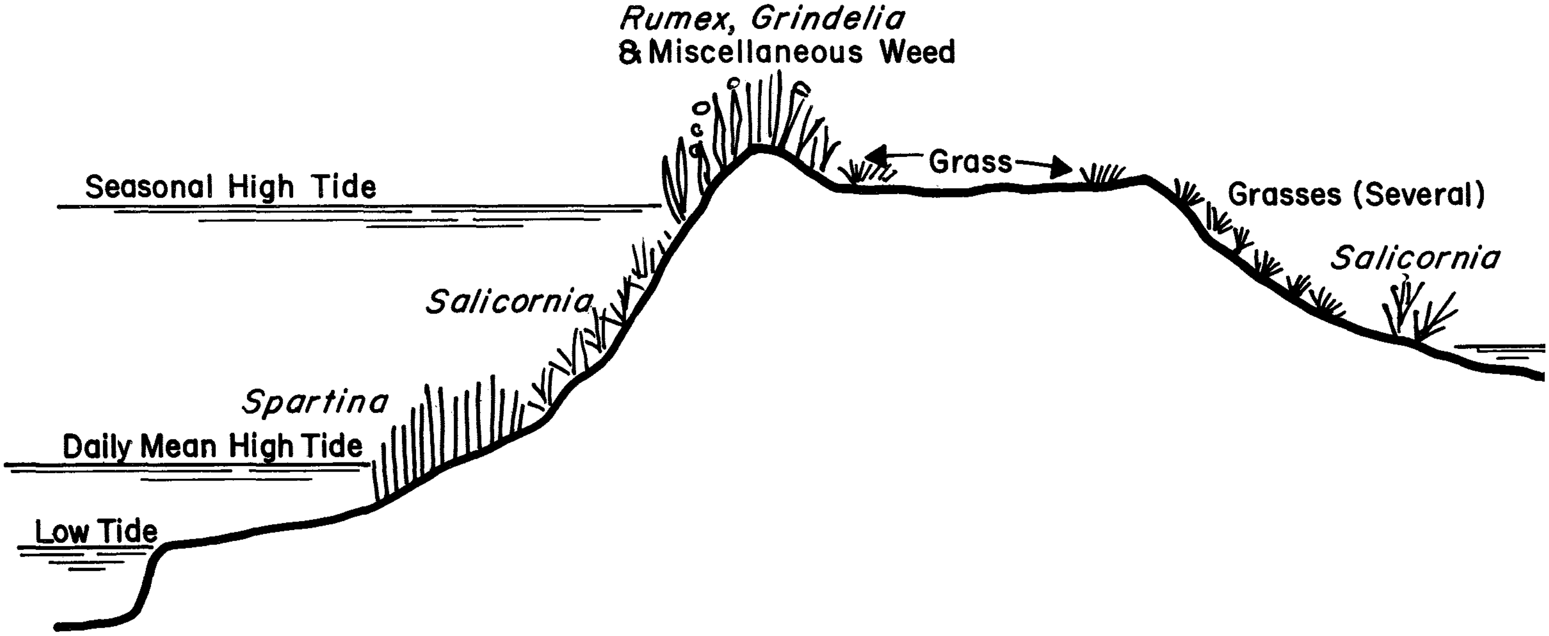
Santa Clara County Baylands Flood Control Planning Study

CROSS SECTION OF SALT POND LEVEE SHOWING EFFECT OF SALT SPRAY ON VEGETATION

TUDOR ENGINEERING COMPANY – CONSULTING ENGINEERS AND PLANNERS
PHILIP H. AREND – WILDLIFE ASSOCIATES

7
PLATE

MARCH 1972



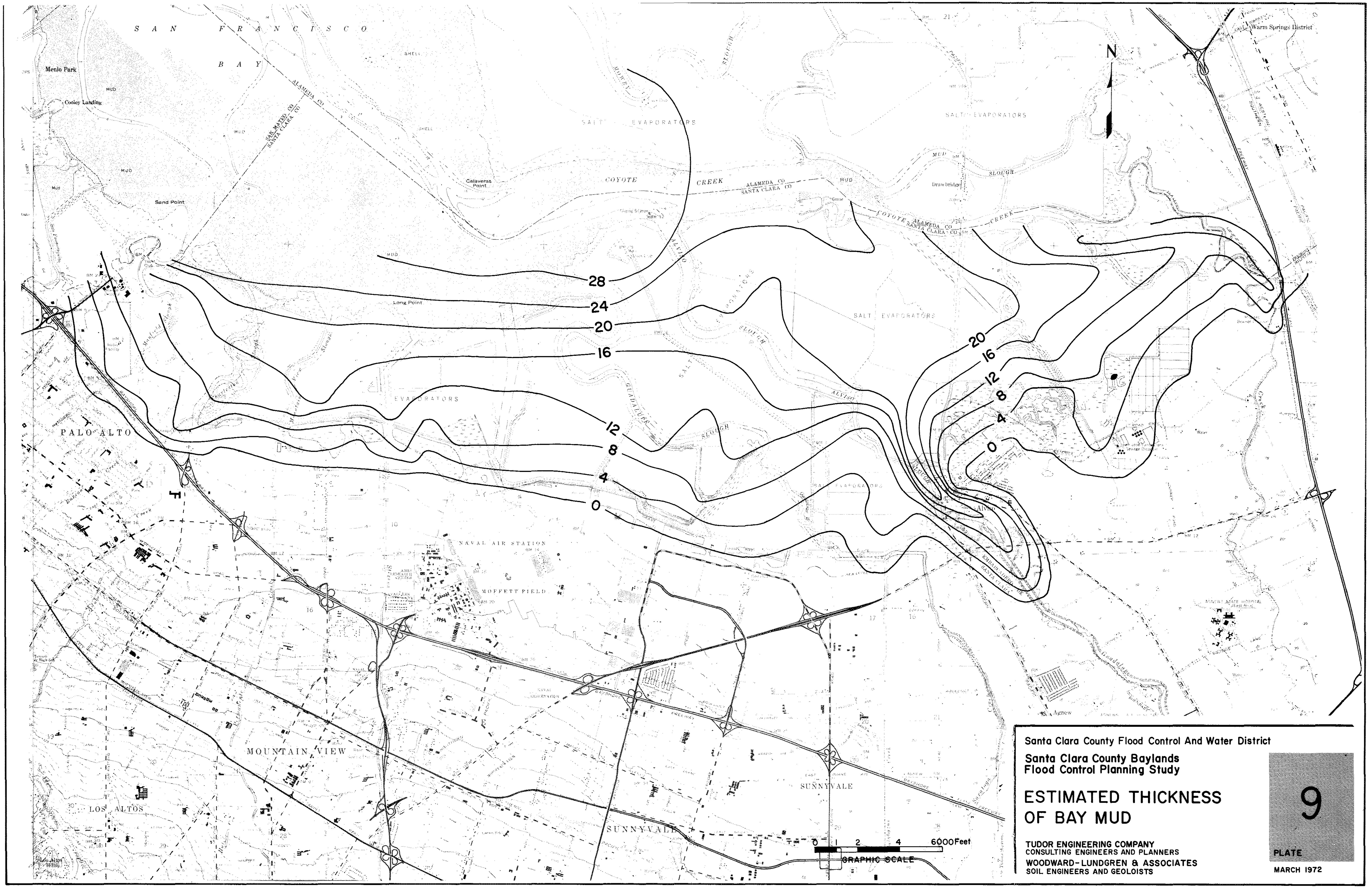
Santa Clara County Flood Control And Water District

Santa Clara County Baylands Flood Control Planning Study
CROSS SECTION OF STEVENS CREEK–POND 2 LEVEE SHOWING VARIED GROWTH ON STABLE SITE WITH LOW SALINITY

TUDOR ENGINEERING COMPANY–CONSULTING ENGINEERS AND PLANNERS
PHILIP H. AREND–WILDLIFE ASSOCIATES

8
PLATE

MARCH 1972



Santa Clara County Flood Control And Water District

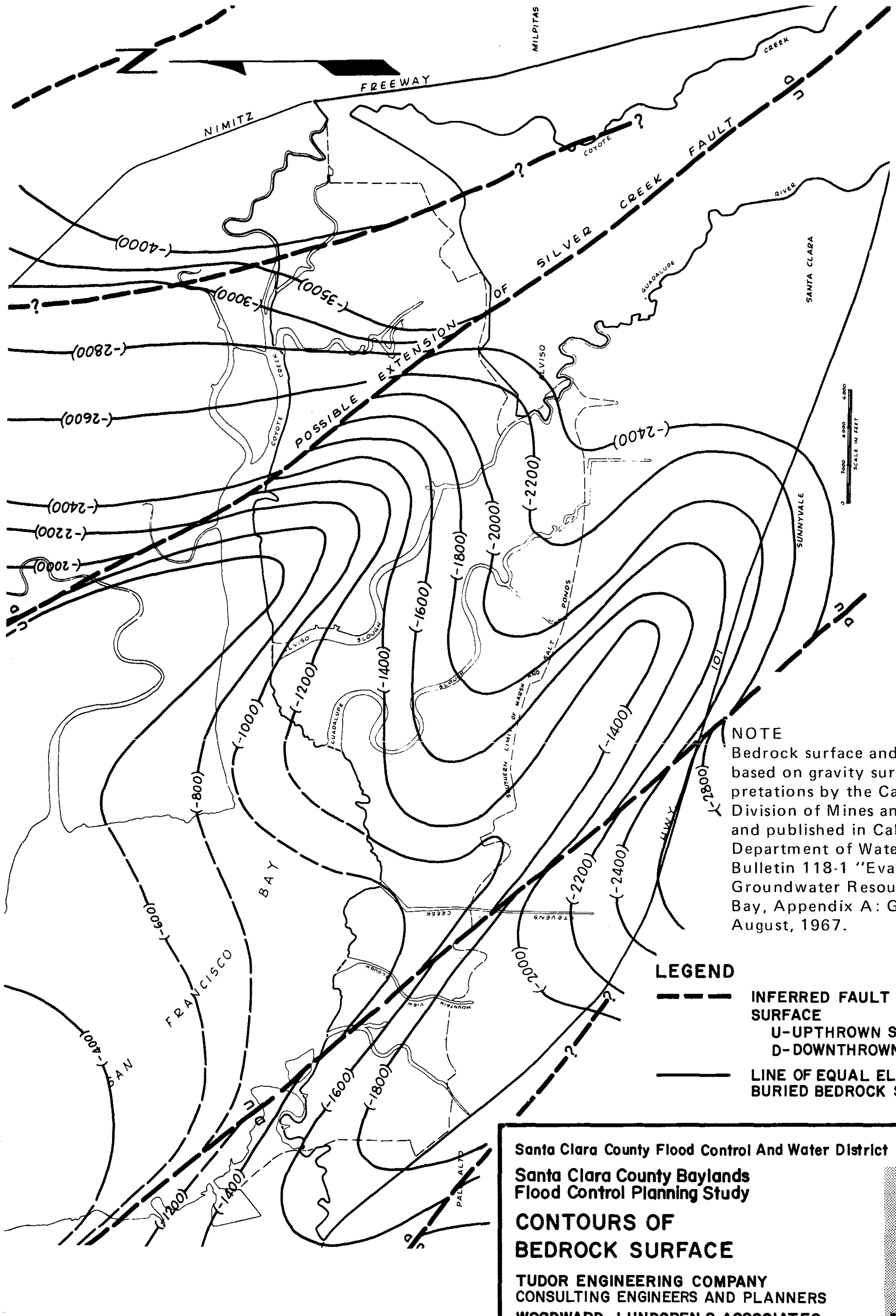
Santa Clara County Baylands
Flood Control Planning Study

ESTIMATED THICKNESS OF BAY MUD

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS
WOODWARD-LUNDGREN & ASSOCIATES
SOIL ENGINEERS AND GEOLOISTS

PLATE 9

MARCH 1972



NOTE
Bedrock surface and faults are based on gravity survey interpretations by the California Division of Mines and Geology and published in California Department of Water Resources, Bulletin 118-1 "Evaluation of Groundwater Resources—South Bay, Appendix A: Geology" August, 1967.

LEGEND

— — — INFERRED FAULT IN BEDROCK SURFACE
U-UPTHROWN SIDE
D-DOWNTHROWN SIDE

——— LINE OF EQUAL ELEVATION OF BURIED BEDROCK SURFACE

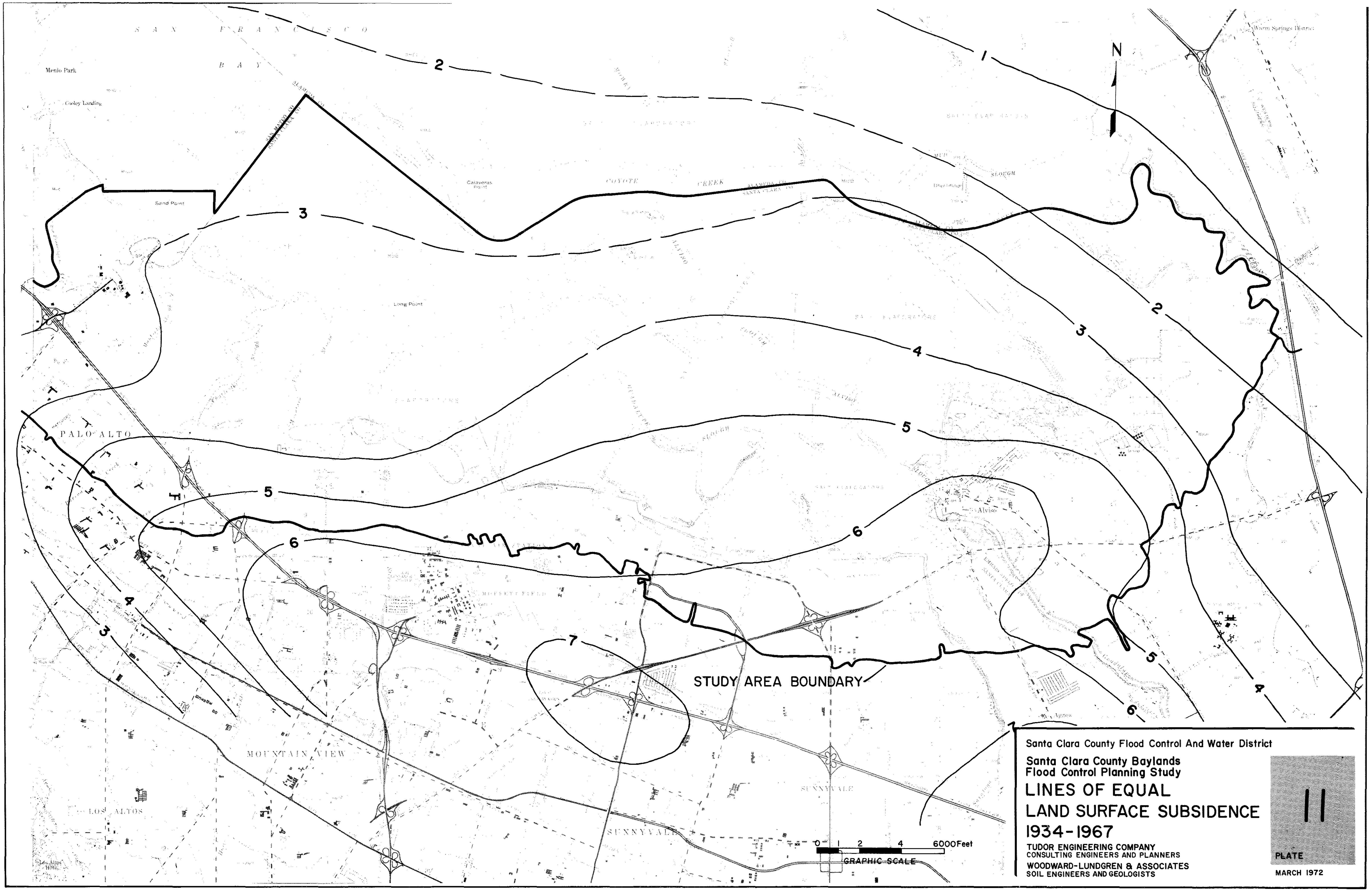
Santa Clara County Flood Control And Water District

Santa Clara County Baylands
Flood Control Planning Study

CONTOURS OF BEDROCK SURFACE

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS
WOODWARD-LUNDGREN & ASSOCIATES
SOIL ENGINEERS AND GEOLOGISTS

10
PLATE
MARCH 1972



Santa Clara County Flood Control And Water District

Santa Clara County Baylands
Flood Control Planning Study

LINES OF EQUAL LAND SURFACE SUBSIDENCE 1934-1967

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS
WOODWARD-LUNDGREN & ASSOCIATES
SOIL ENGINEERS AND GEOLOGISTS

PLATE 11

MARCH 1972

Santa Clara County Flood Control And Water District

Santa Clara County Baylands Flood Control Planning Study

TYPICAL SUBSURFACE PROFILES

TUDOR ENGINEERING COMPANY-CONSULTING ENGINEERS AND PLANNERS
WOODWARD-LUNDGREN & ASSOCIATES-SOIL ENGINEERS AND GEOLOGISTS

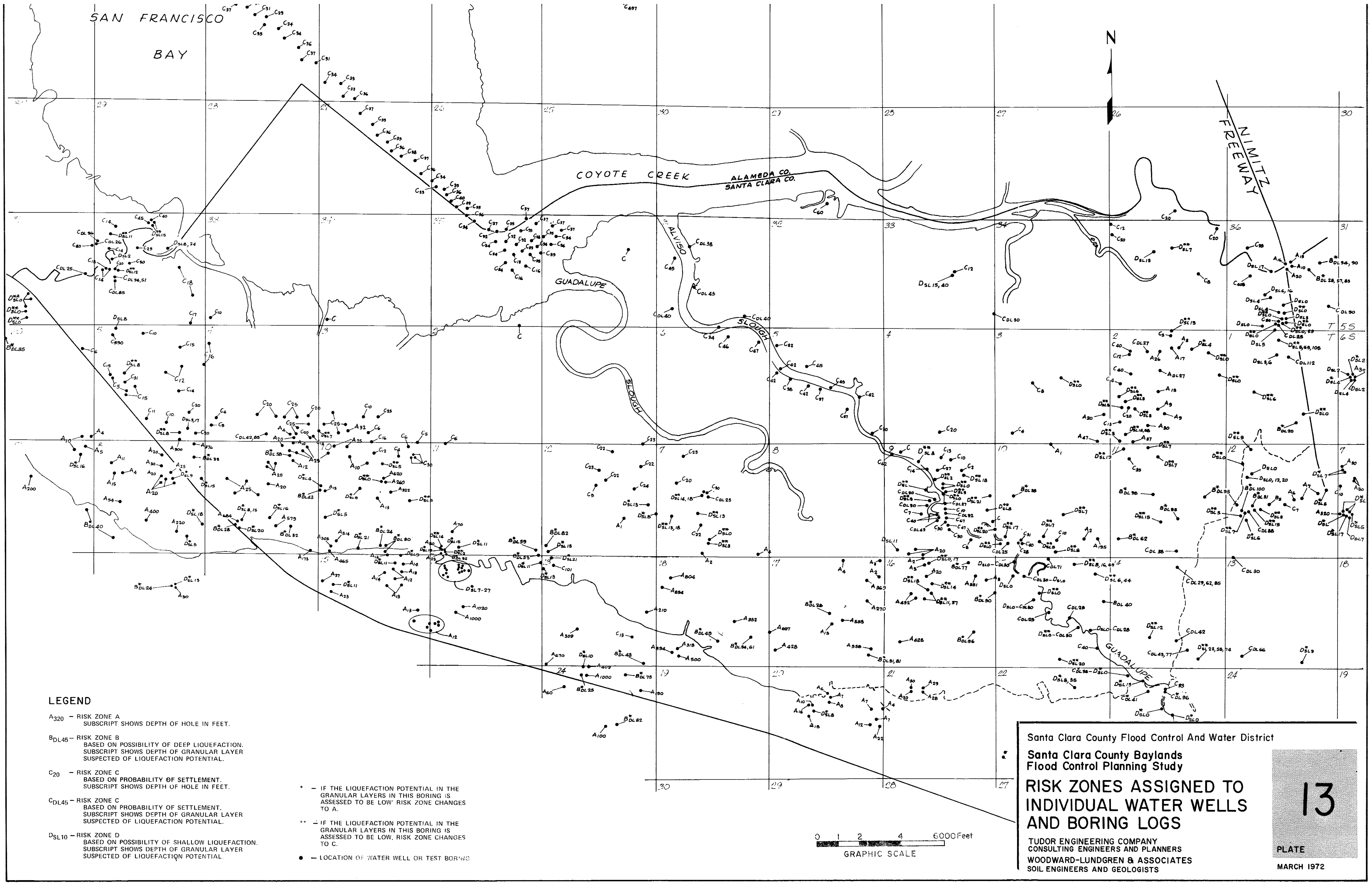
PLATE 12

MARCH 1972

Profile Type	I	II	III	IV	V
Subsurface Profile	Stiff Clay	Stiff Clay Sand And Gravel Stiff Clay	Firm Clay Sand Or Sand And Gravel Stiff Clay Sand And Gravel Stiff Clay	Sand Bay Mud Or Soft Clay Stiff Clay Sand And Gravel Stiff Clay	Bay Mud Stiff Clay Sand And Gravel Stiff Clay
Geologic Condition	Alluvium	Alluvium	Alluvium	Sand And Soft Clay Over Alluvium	Bay Mud Over Alluvium
Risk Zone	A	B*	D*	D**	C

* IF THE LIQUEFACTION POTENTIAL IN THE GRANULAR LAYERS IN THIS PROFILE IS ASSESSED TO BE NIL OR VERY LOW, THE RISK ZONE IS CHANGED TO A.

** IF THE LIQUEFACTION POTENTIAL IN THE GRANULAR LAYERS IN THIS PROFILE IS ASSESSED TO BE NIL OR VERY LOW, THE RISK ZONE IS CHANGED TO C.



LEGEND

A_{320} – RISK ZONE A
SUBSCRIPT SHOWS DEPTH OF HOLE IN FEET.

B_{DL45} – RISK ZONE B
BASED ON POSSIBILITY OF DEEP LIQUEFACTION.
SUBSCRIPT SHOWS DEPTH OF GRANULAR LAYER
SUSPECTED OF LIQUEFACTION POTENTIAL.

C_{20} – RISK ZONE C
BASED ON PROBABILITY OF SETTLEMENT.
SUBSCRIPT SHOWS DEPTH OF HOLE IN FEET.

C_{DL45} – RISK ZONE C
BASED ON PROBABILITY OF SETTLEMENT.
SUBSCRIPT SHOWS DEPTH OF GRANULAR LAYER
SUSPECTED OF LIQUEFACTION POTENTIAL.

D_{SL10} – RISK ZONE D
BASED ON POSSIBILITY OF SHALLOW LIQUEFACTION.
SUBSCRIPT SHOWS DEPTH OF GRANULAR LAYER
SUSPECTED OF LIQUEFACTION POTENTIAL.

* – IF THE LIQUEFACTION POTENTIAL IN THE GRANULAR LAYERS IN THIS BORING IS ASSESSED TO BE LOW RISK ZONE CHANGES TO A.

** – IF THE LIQUEFACTION POTENTIAL IN THE GRANULAR LAYERS IN THIS BORING IS ASSESSED TO BE LOW, RISK ZONE CHANGES TO C.

● – LOCATION OF WATER WELL OR TEST BORING

Santa Clara County Flood Control And Water District

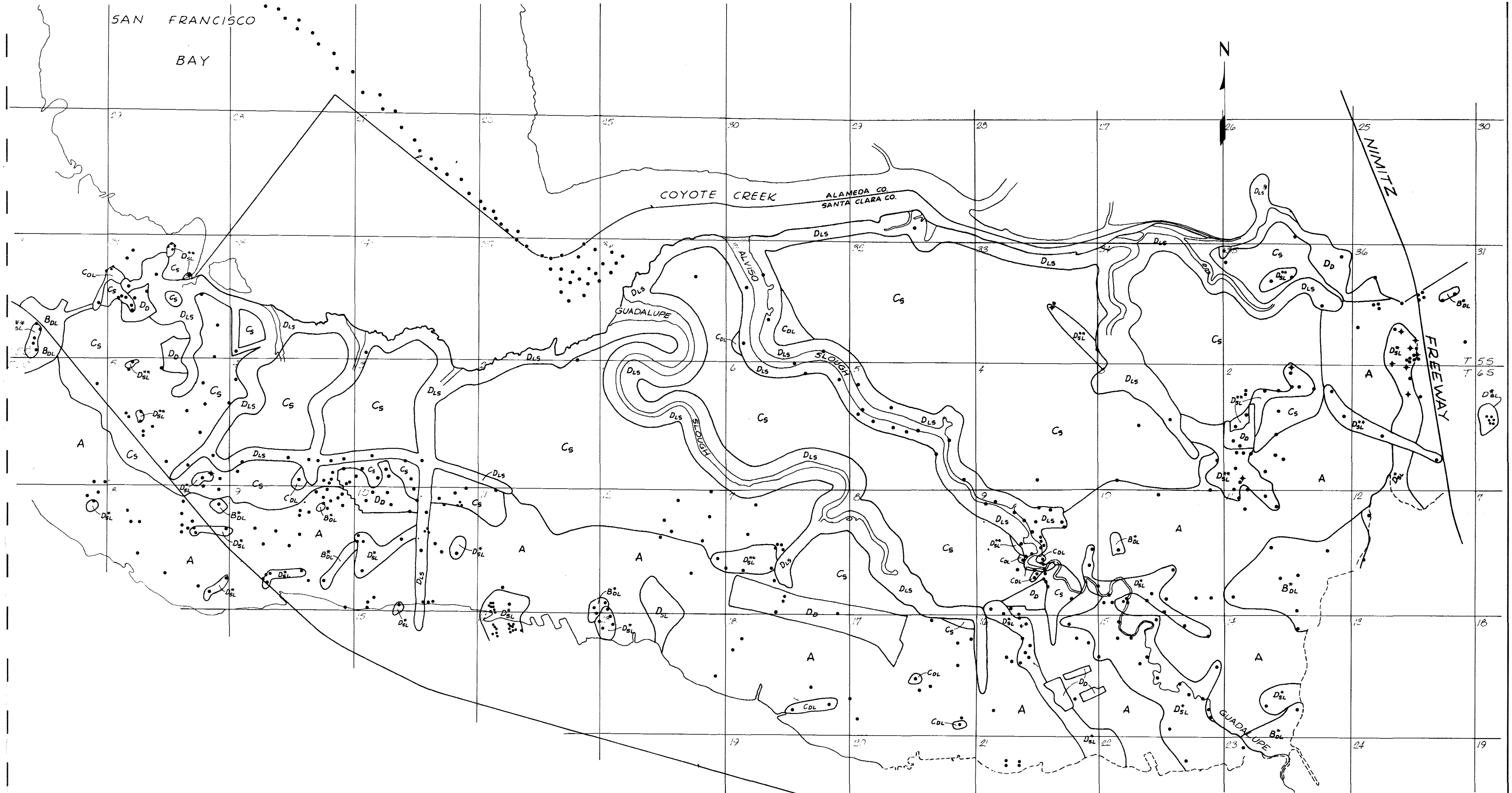
Santa Clara County Baylands
Flood Control Planning Study

RISK ZONES ASSIGNED TO INDIVIDUAL WATER WELLS AND BORING LOGS

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS
WOODWARD-LUNDGREN & ASSOCIATES
SOIL ENGINEERS AND GEOLOGISTS

13
PLATE

MARCH 1972



LEGEND

A – RISK ZONE A

B_{DL} – RISK ZONE B
BASED ON POSSIBILITY OF DEEP LIQUEFACTION.

C_{DL} – RISK ZONE C
BASED ON PROBABILITY OF SETTLEMENT AND POSSIBILITY OF DEEP LIQUEFACTION.

C_S – RISK ZONE C
BASED ON PROBABILITY OF SETTLEMENT.

D_D – RISK ZONE D
BASED ON PRESENCE OF UNCONTROLLED DUMP FILL.

D_{LS} – RISK ZONE D
BASED ON POSSIBILITY OF LATERAL SPREADING.

D_{SL} – RISK ZONE D
BASED ON POSSIBILITY OF SHALLOW LIQUEFACTION.

* – IF THE LIQUEFACTION POTENTIAL IN THE GRANULAR LAYERS IN THIS ZONE IS ASSESSED TO BE LOW, RISK ZONE CHANGES TO A.

** – IF THE LIQUEFACTION POTENTIAL IN THE GRANULAR LAYERS IN THIS ZONE IS ASSESSED TO BE LOW, RISK ZONE CHANGES TO C.

● – LOCATION OF WATER WELL OR ENGINEERING BORING.

✦ – LOCATION OF ENGINEERING BORING SPECIFYING "LOOSE" SAND.

NOTE:

THE DELINEATION OF RISK ZONES IS BASED ON THE LOGS OF THE WATER WELLS AND ENGINEERING BORINGS SHOWN. THE DENSITY OF THESE DATA POINTS IS A MEASURE OF RELATIVE RELIABILITY OF THE RISK ZONE DESIGNATIONS ASSIGNED. RISK ZONE BOUNDARIES AND DESIGNATIONS MAY CHANGE AS MORE SUBSURFACE INFORMATION BECOMES AVAILABLE

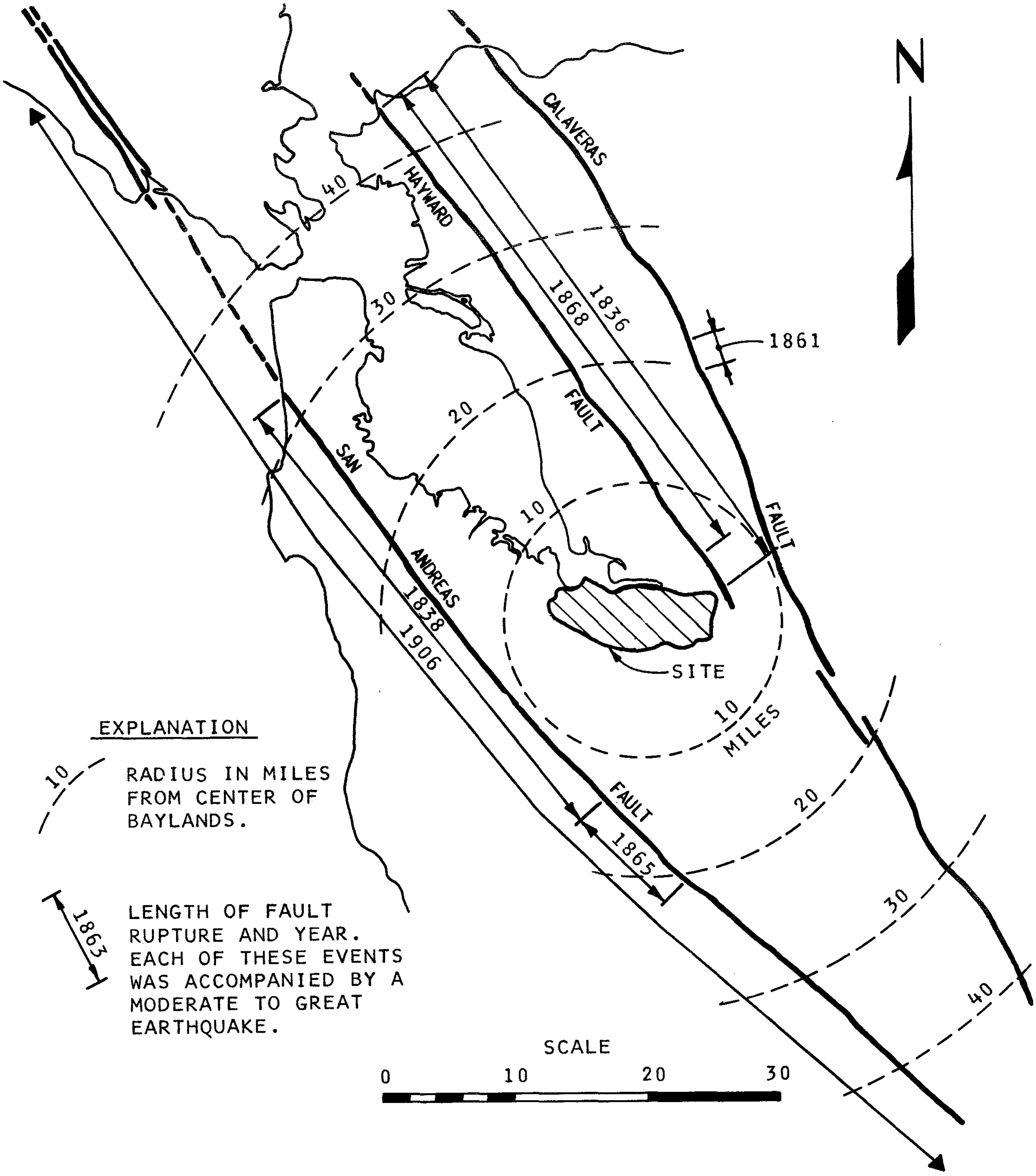
Santa Clara County Flood Control And Water District

Santa Clara County Baylands
Flood Control Planning Study

GEOLOGIC RISK ZONES
BASED ON SOIL CONDITIONS

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS
WOODWARD-LUNDGREN & ASSOCIATES
SOIL ENGINEERS AND GEOLOGISTS

14
PLATE
MARCH 1972



EXPLANATION

RADIUS IN MILES FROM CENTER OF BAYLANDS.

LENGTH OF FAULT RUPTURE AND YEAR. EACH OF THESE EVENTS WAS ACCOMPANIED BY A MODERATE TO GREAT EARTHQUAKE.

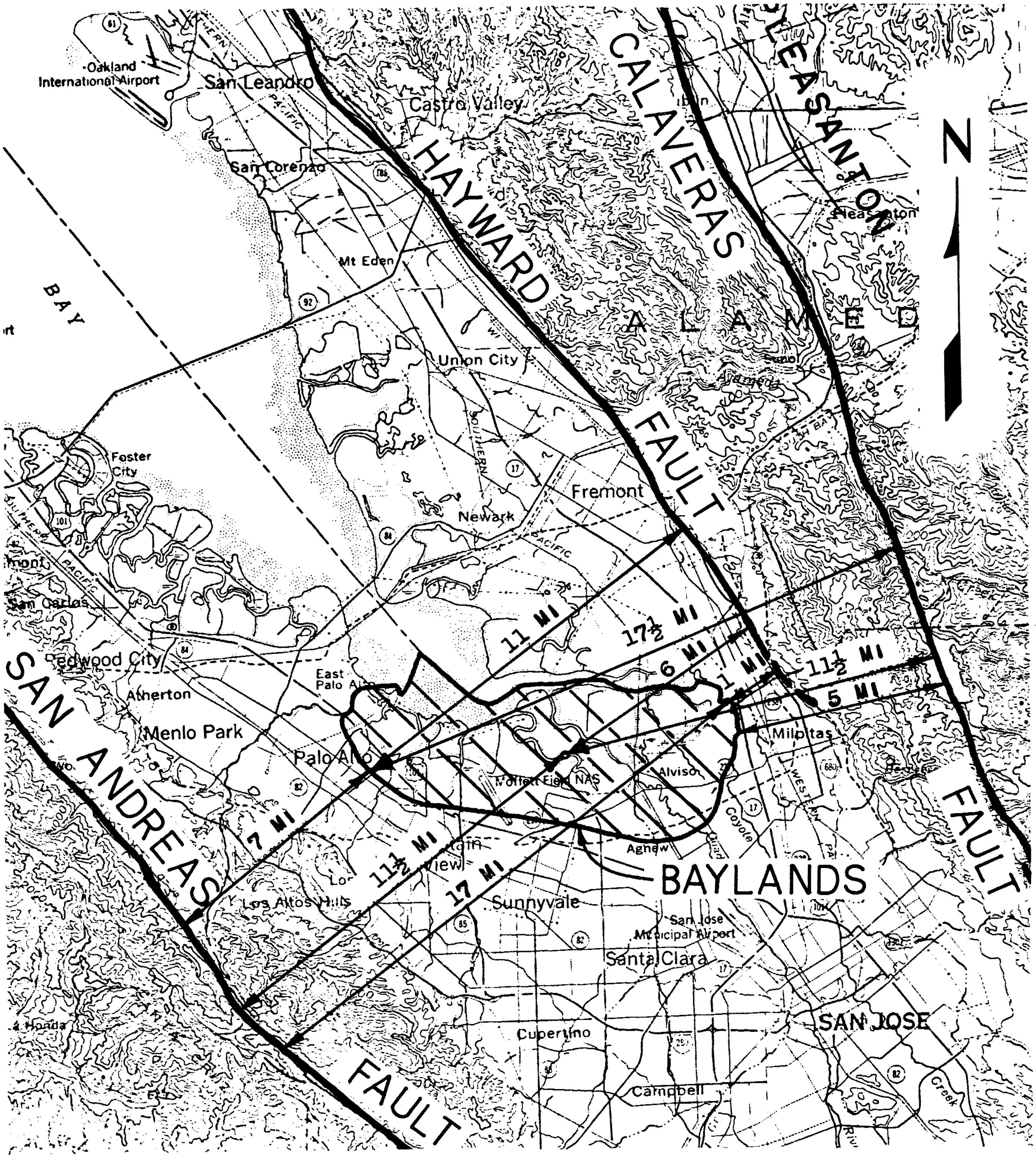
Santa Clara County Flood Control And Water District

Santa Clara County Baylands Flood Control Planning Study

HISTORIC FAULT DISPLACEMENT NEAR THE BAYLANDS

TUDOR ENGINEERING COMPANY-CONSULTING ENGINEERS AND PLANNERS
WOODWARD-LUNDGREN & ASSOCIATES-SOIL ENGINEERS AND GEOLOGISTS

15
PLATE
MARCH 1972



Santa Clara County Flood Control And Water District

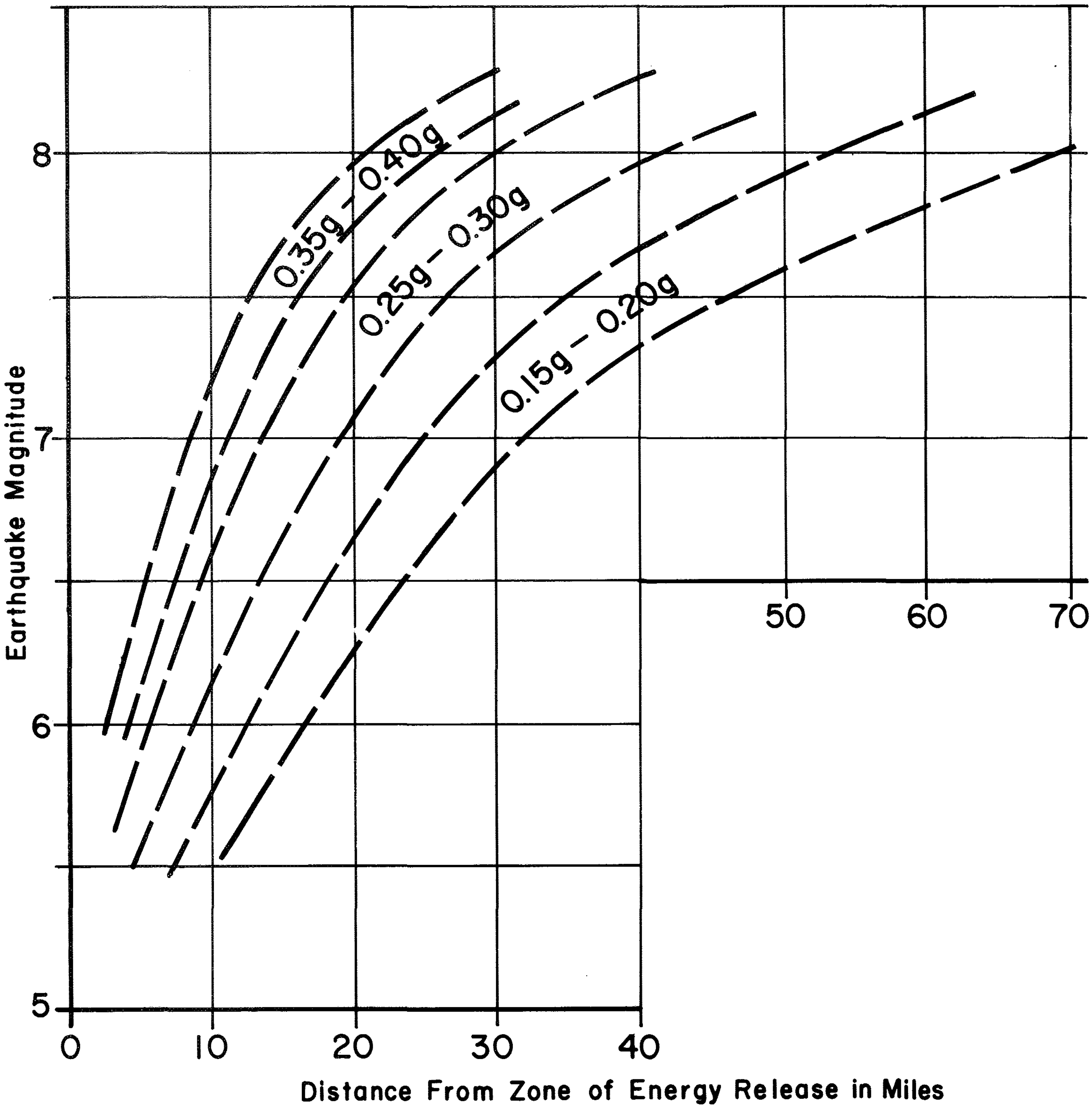
Santa Clara County Baylands Flood Control Planning Study

POSITION OF BAYLANDS
RELATIVE TO ACTIVE FAULTS

TUDOR ENGINEERING COMPANY - CONSULTING ENGINEERS AND PLANNERS
WOODWARD-LUNDGREN & ASSOCIATES - SOIL ENGINEERS AND GEOLOGIST

PLATE 16

MARCH 1972



Santa Clara County Flood Control And Water District

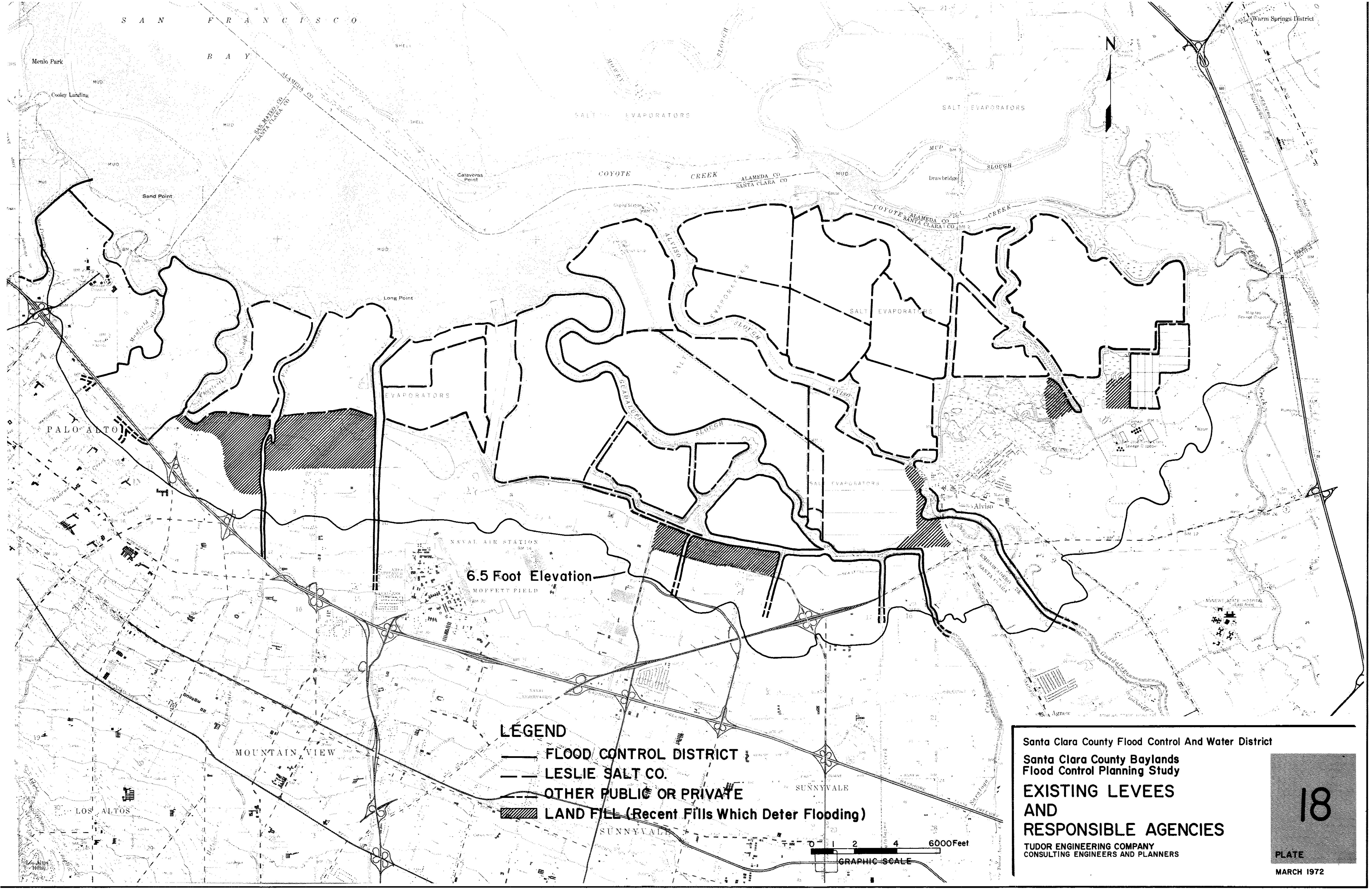
Santa Clara County Baylands Flood Control Planning Study

ESTIMATED GROUND SURFACE ACCELERATION DUE TO EARTHQUAKES

TUDOR ENGINEERING COMPANY - CONSULTING ENGINEERS AND PLANNERS
WOODWARD-LUNDGREN & ASSOCIATES - SOIL ENGINEERS AND GEOLOGISTS

PLATE 17

MARCH 1972



Santa Clara County Flood Control And Water District

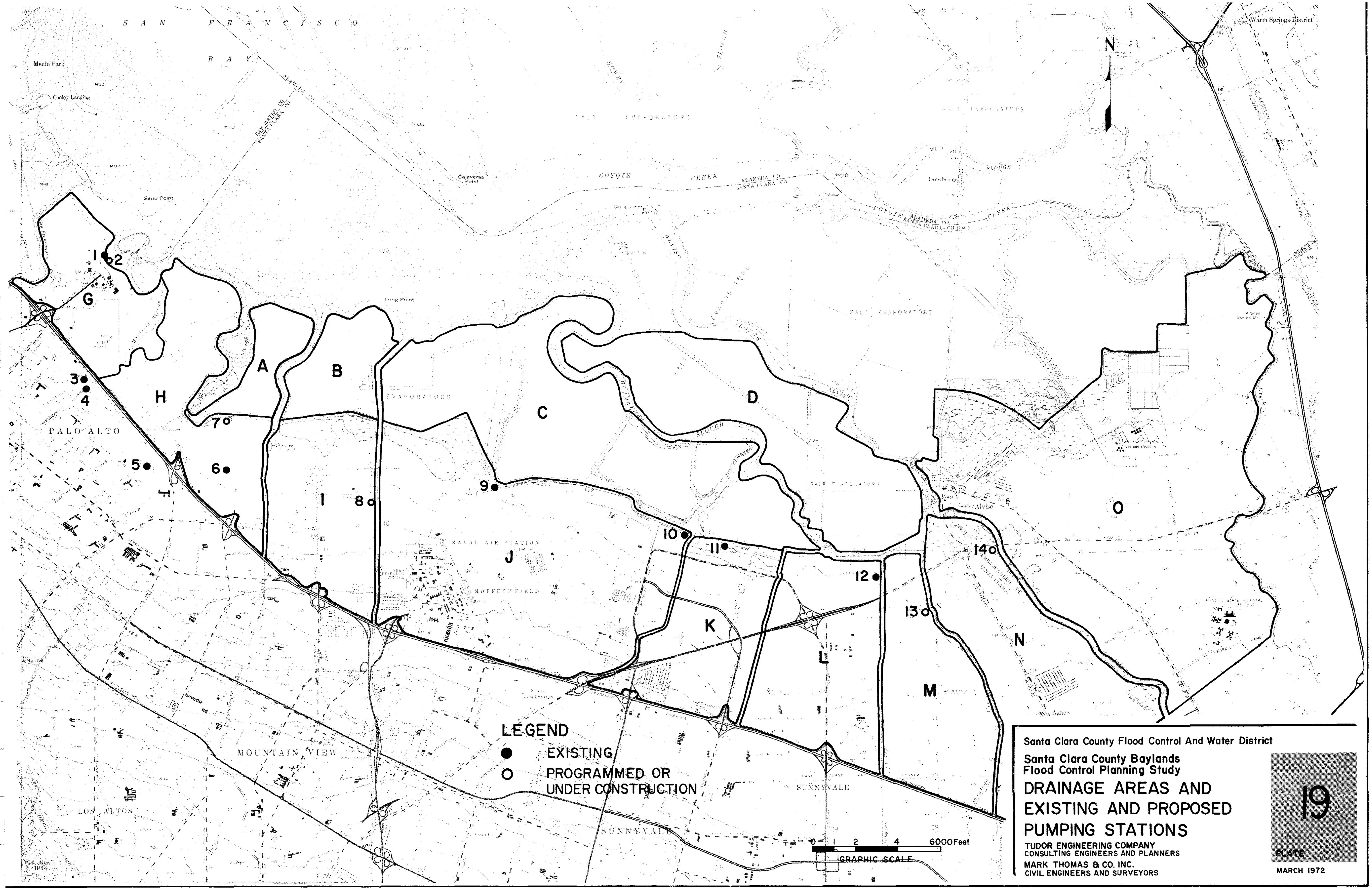
Santa Clara County Baylands
Flood Control Planning Study

EXISTING LEVEES AND RESPONSIBLE AGENCIES

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS

PLATE 18

MARCH 1972



Santa Clara County Flood Control And Water District

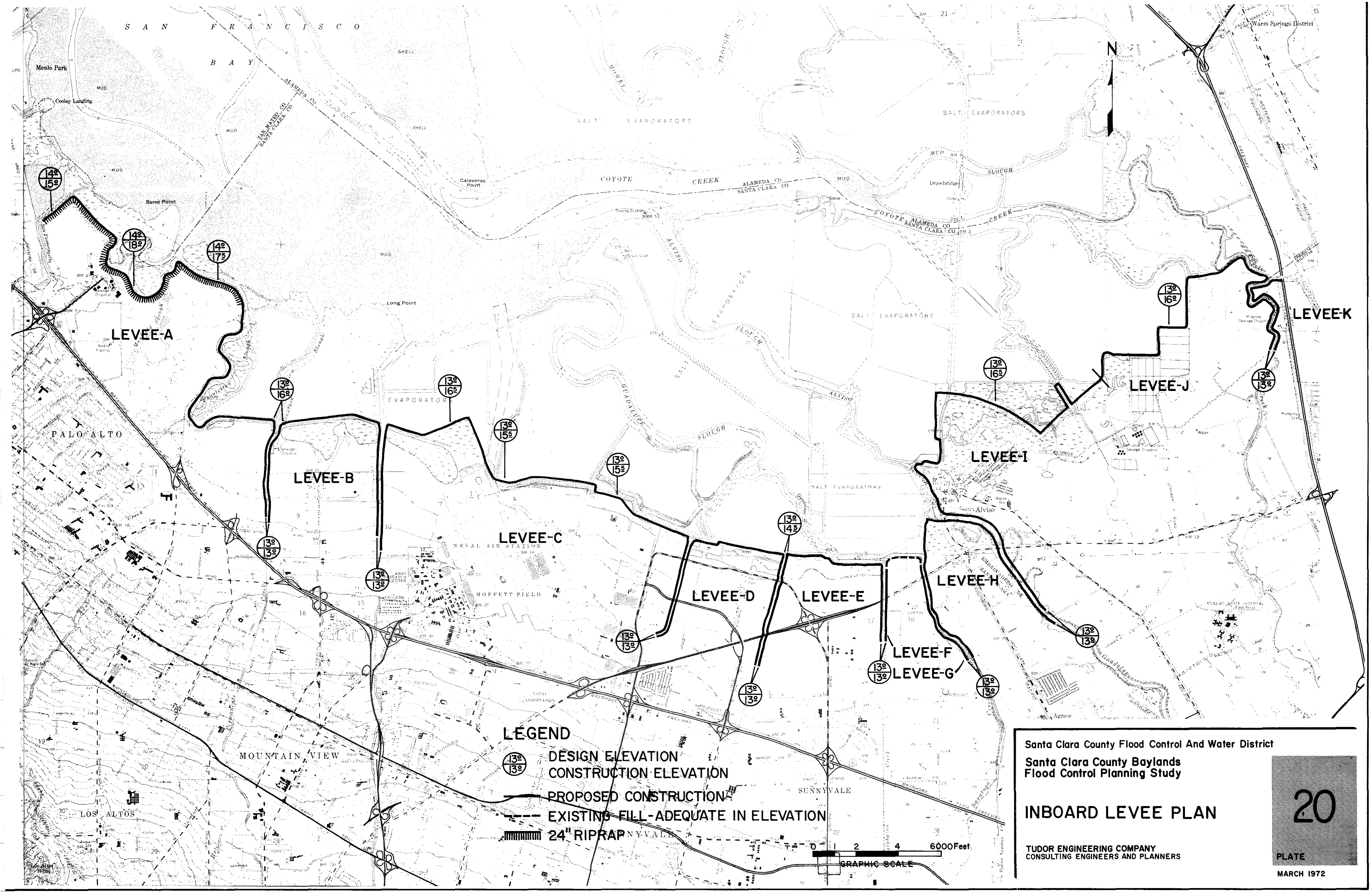
Santa Clara County Baylands
Flood Control Planning Study

DRAINAGE AREAS AND EXISTING AND PROPOSED PUMPING STATIONS

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS
MARK THOMAS & CO. INC.
CIVIL ENGINEERS AND SURVEYORS

PLATE 19

MARCH 1972



Santa Clara County Flood Control And Water District

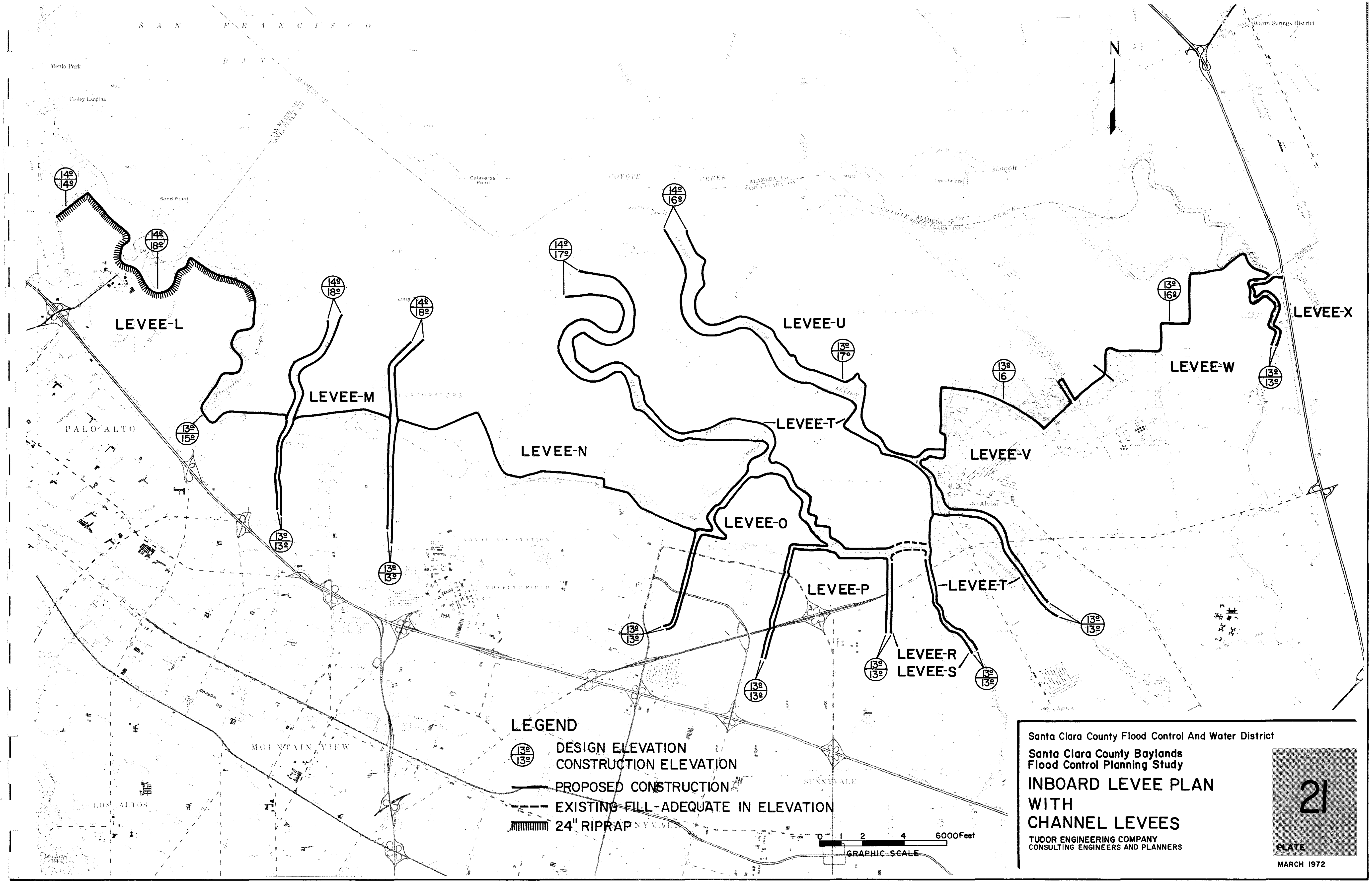
Santa Clara County Baylands
Flood Control Planning Study

INBOARD LEVEE PLAN

PLATE 20

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS

MARCH 1972



Santa Clara County Flood Control And Water District

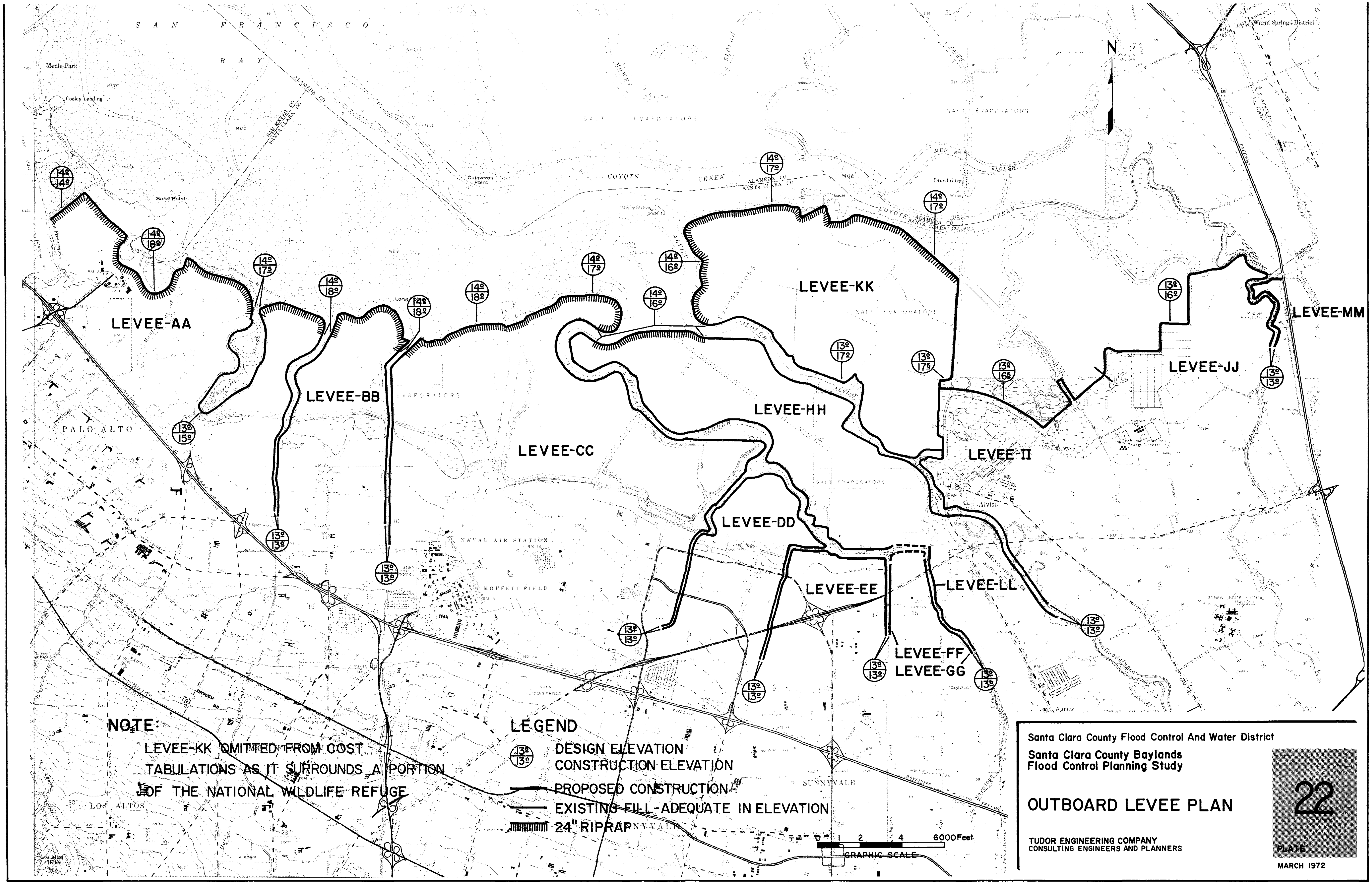
Santa Clara County Baylands
Flood Control Planning Study

INBOARD LEVEE PLAN
WITH
CHANNEL LEVEES

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS

PLATE 21

MARCH 1972



NOTE:

LEVEE-KK OMITTED FROM COST TABULATIONS AS IT SURROUNDS A PORTION OF THE NATIONAL WILDLIFE REFUGE

LEGEND

13º/13º	DESIGN ELEVATION CONSTRUCTION ELEVATION
━	PROPOSED CONSTRUCTION
─	EXISTING FILL-ADEQUATE IN ELEVATION
▥	24" RIPRAP

Santa Clara County Flood Control And Water District

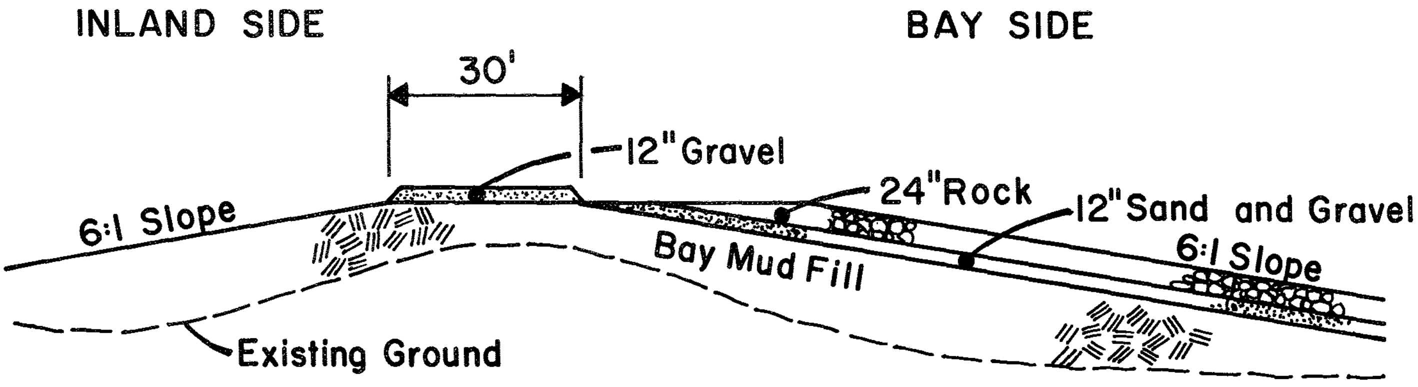
Santa Clara County Baylands
Flood Control Planning Study

OUTBOARD LEVEE PLAN

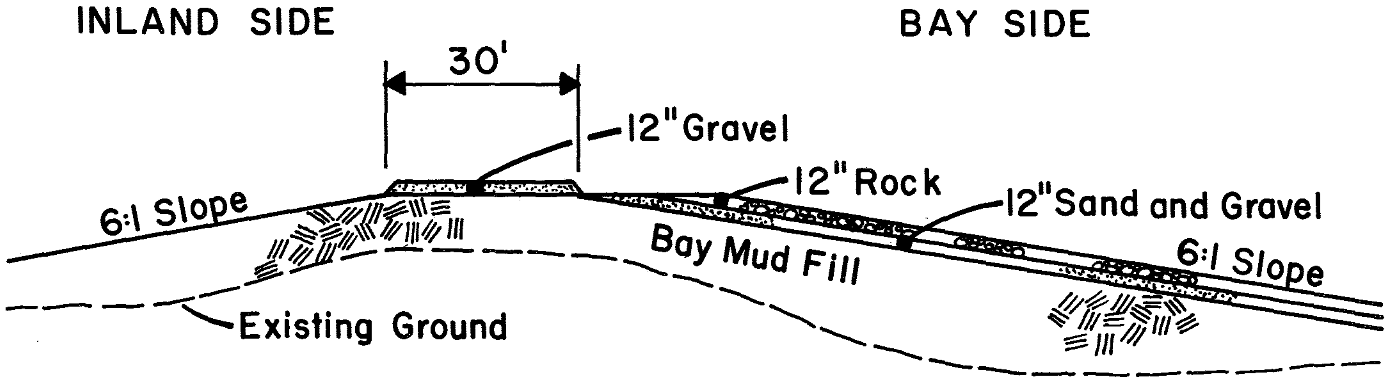
TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS

22
PLATE

MARCH 1972



TYPICAL SECTION
OUTBOARD LEVEE



TYPICAL SECTION
INBOARD LEVEE

Santa Clara County Flood Control And Water District

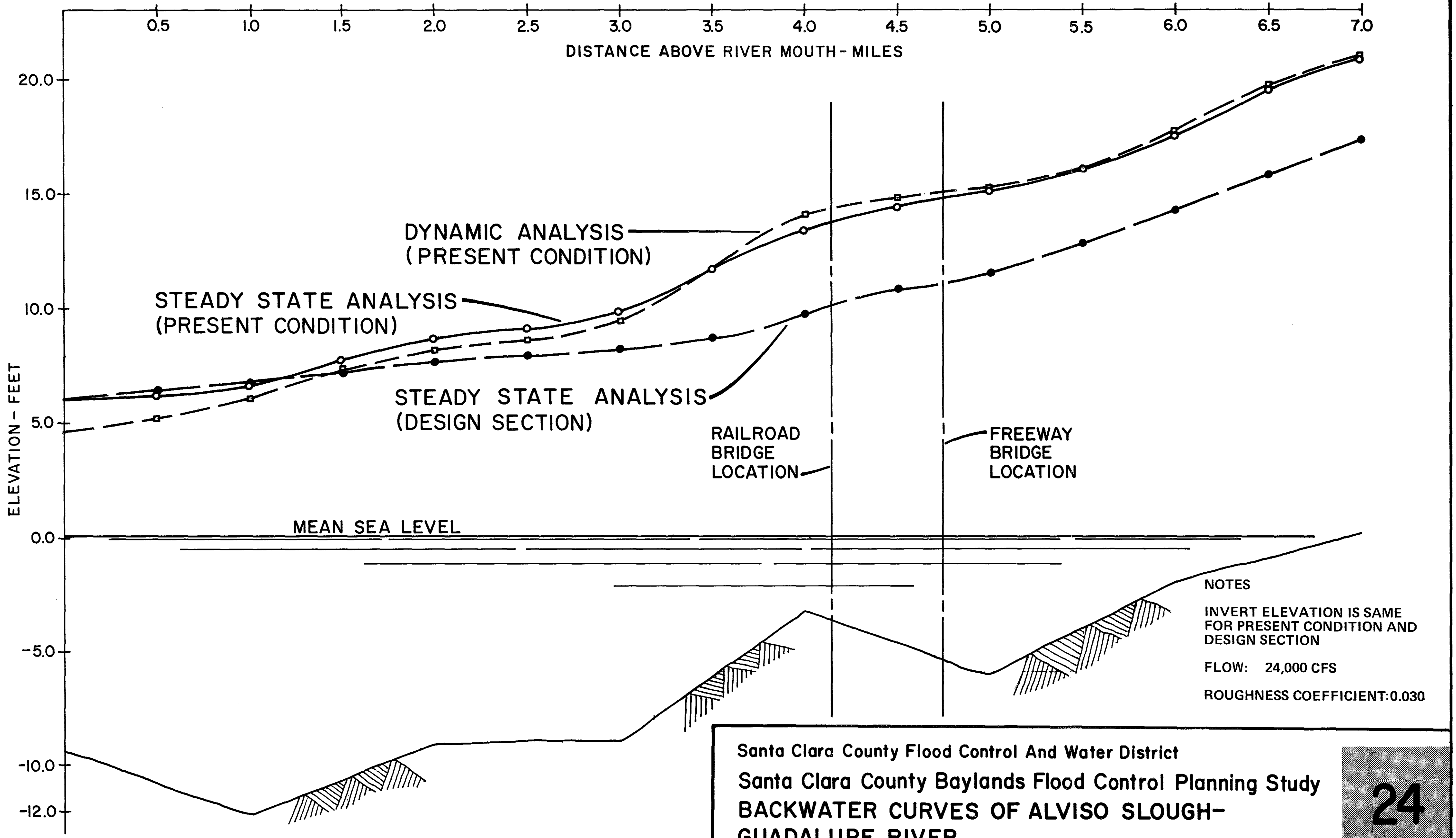
Santa Clara County Baylands Flood Control Planning Study

TYPICAL SECTION
OUTBOARD LEVEE AND INBOARD LEVEE

TUDOR ENGINEERING COMPANY – CONSULTING ENGINEERS AND PLANNERS

PLATE 23

MARCH 1972



NOTES

INVERT ELEVATION IS SAME FOR PRESENT CONDITION AND DESIGN SECTION

FLOW: 24,000 CFS

ROUGHNESS COEFFICIENT: 0.030

Santa Clara County Flood Control And Water District

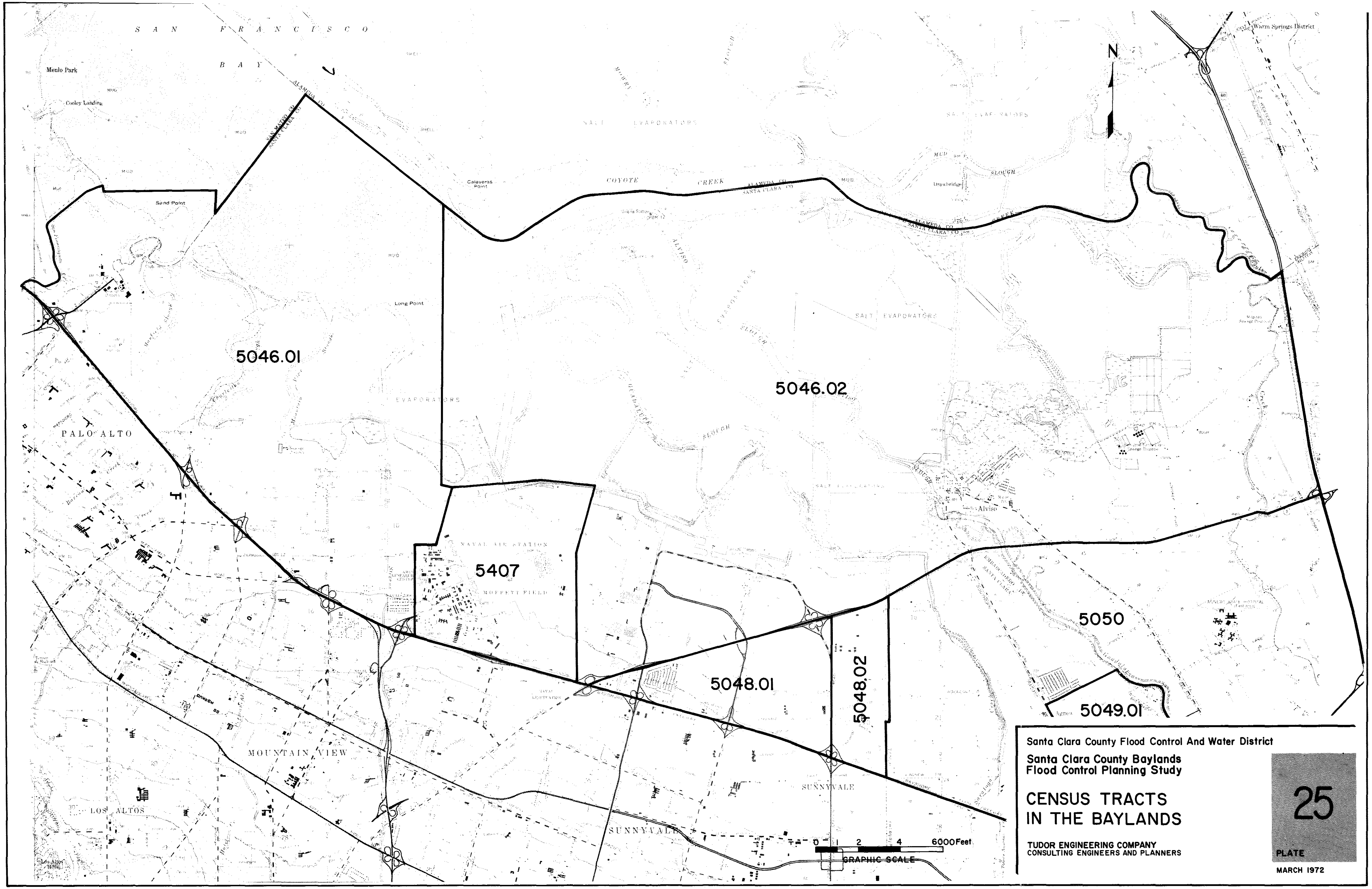
Santa Clara County Baylands Flood Control Planning Study

BACKWATER CURVES OF ALVISO SLOUGH-GUADALUPE RIVER

TUDOR ENGINEERING COMPANY - CONSULTING ENGINEERS AND PLANNERS
HYDROCOMP INTERNATIONAL, JAMES A. HARDER - HYDROLOGISTS

24
PLATE

MARCH 1972



Santa Clara County Flood Control And Water District

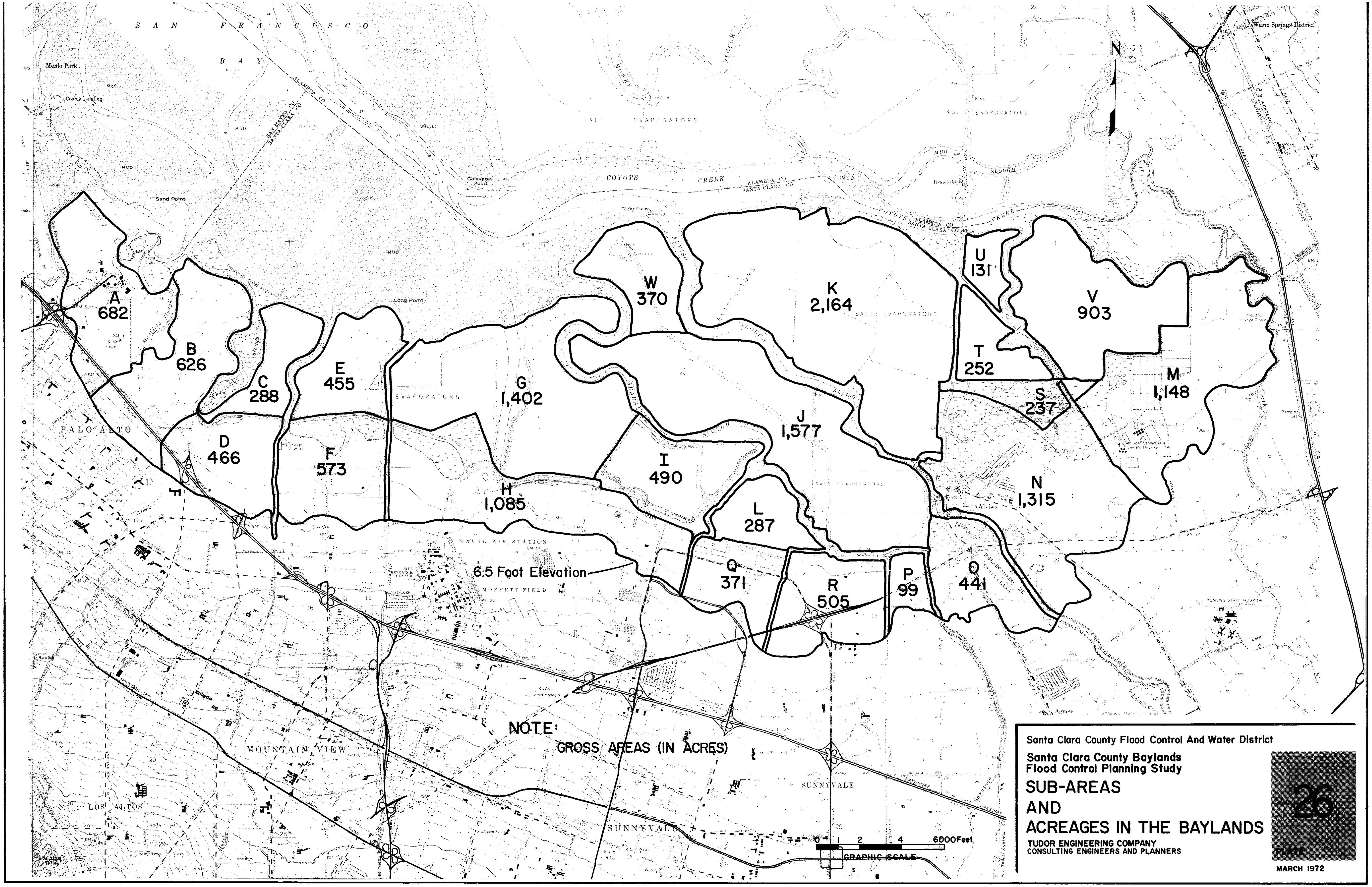
Santa Clara County Baylands
Flood Control Planning Study

CENSUS TRACTS IN THE BAYLANDS

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS

25
PLATE

MARCH 1972



Santa Clara County Flood Control And Water District

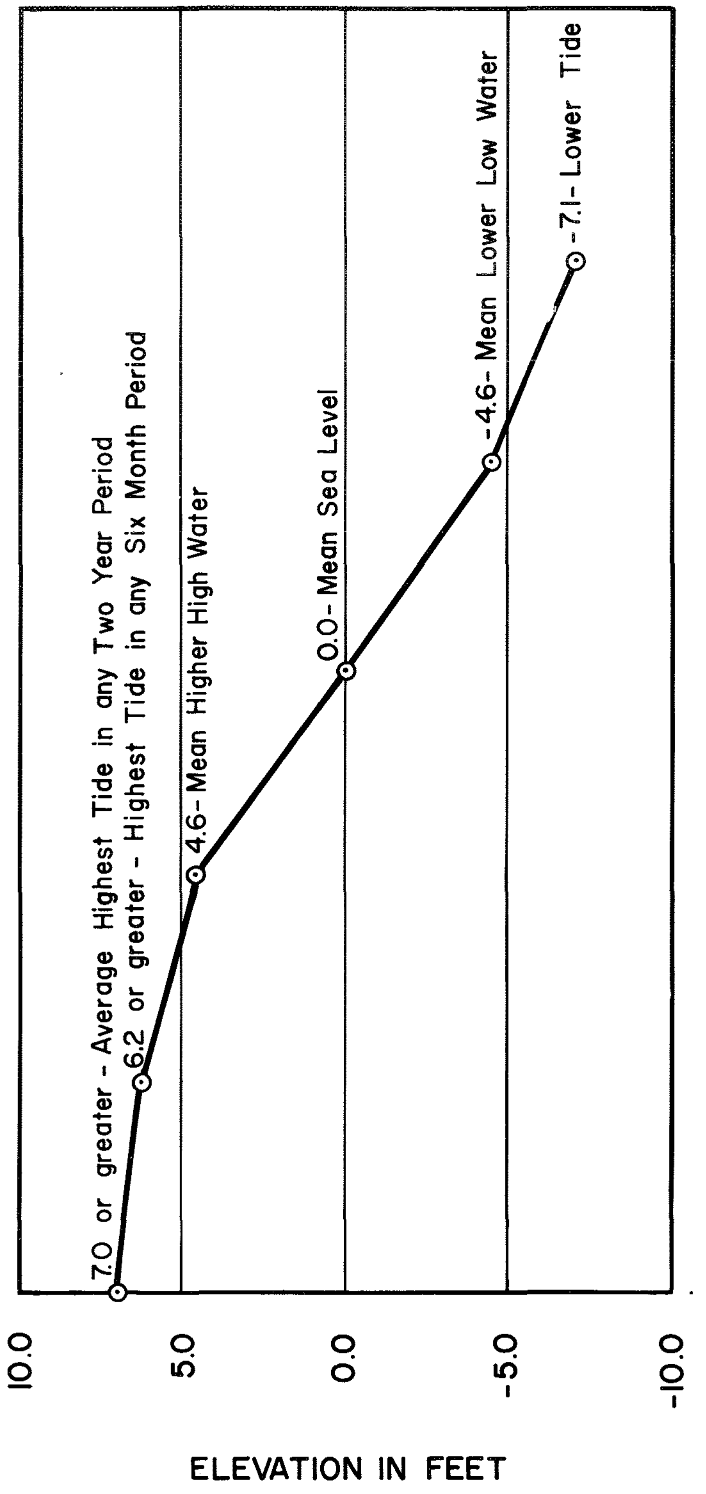
Santa Clara County Baylands
Flood Control Planning Study

SUB-AREAS
AND
ACREAGES IN THE BAYLANDS

TUDOR ENGINEERING COMPANY
CONSULTING ENGINEERS AND PLANNERS

PLATE 26

MARCH 1972



Santa Clara County Flood Control And Water District

Santa Clara County Baylands Flood Control Planning Study

TIDE LEVEL DIAGRAM
MOUTH OF ALVISO SLOUGH

TUDOR ENGINEERING COMPANY - CONSULTING ENGINEERS AND PLANNERS

27

PLATE